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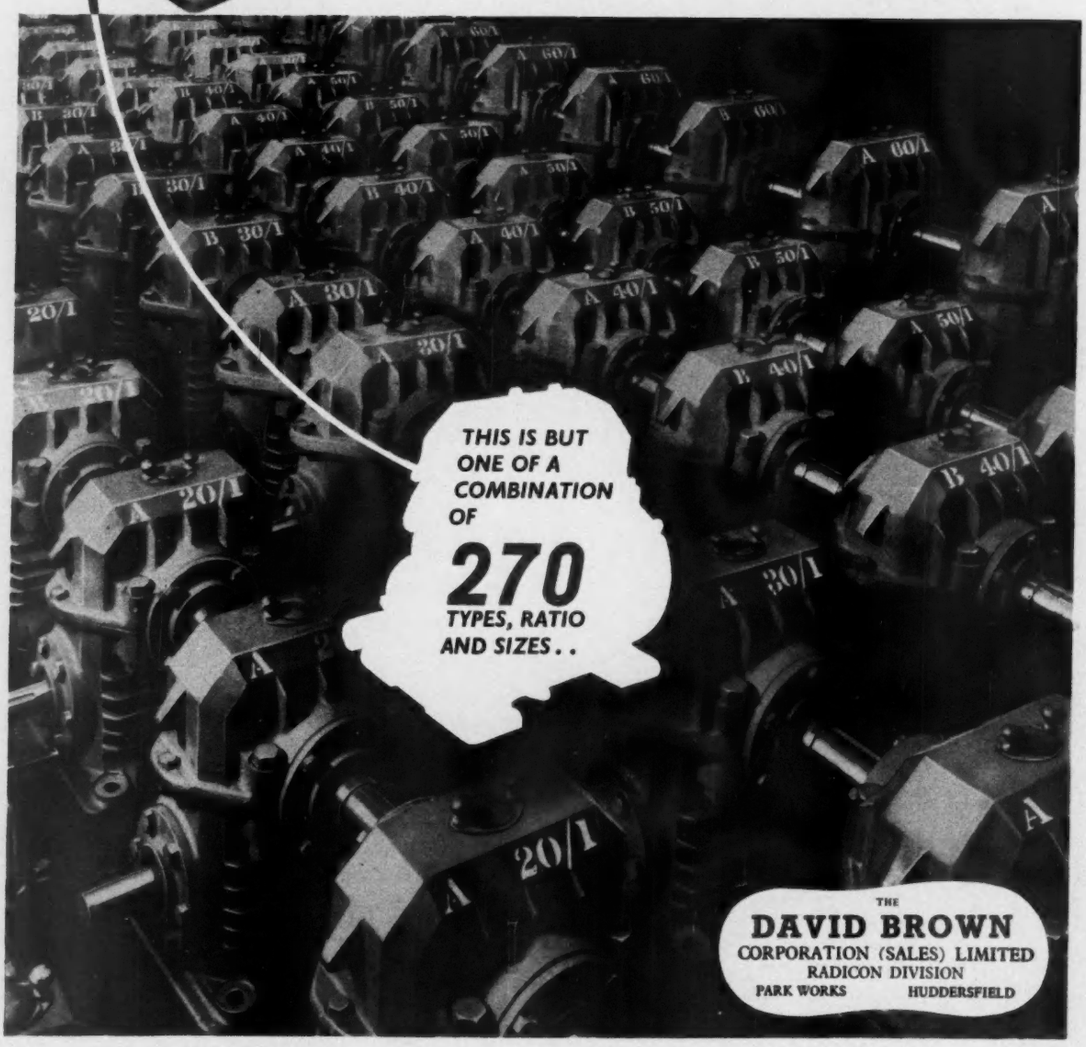

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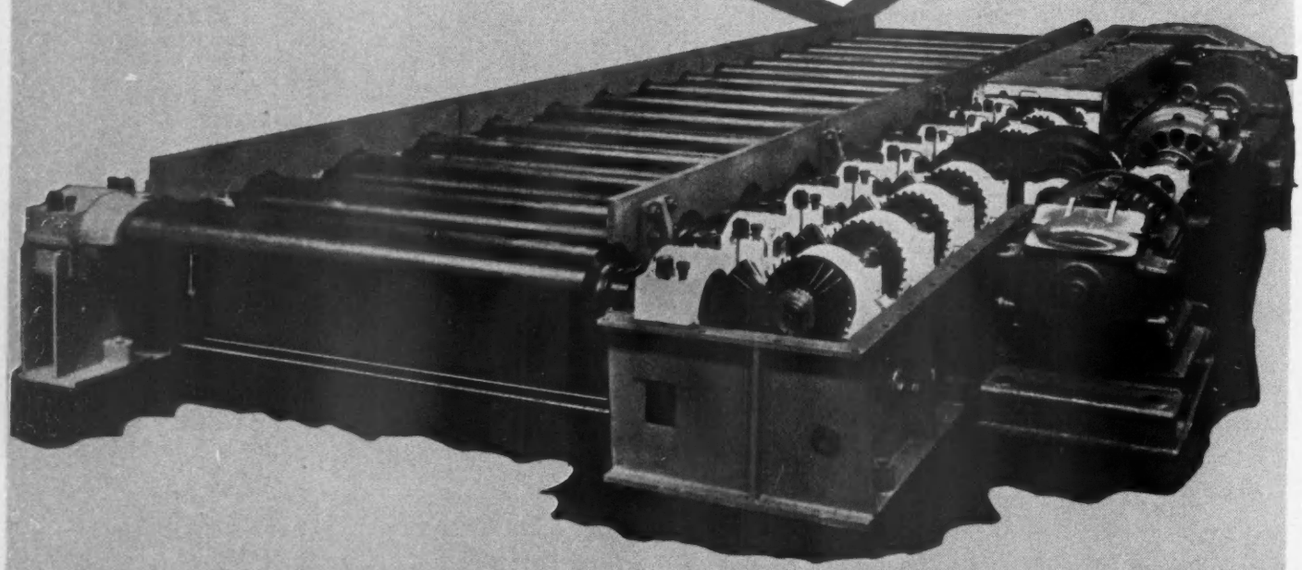

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THE ENGINEER

Established 1856

No. 5350 AUGUST 8, 1958 VOL. 206

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SUBSCRIPTIONS U.K. and ABROAD £5 10. 0. p.a., including postage (CANADA £5 5. 0.). Single copies 2s. each, plus 9d. postage. Also on sale at newsagents.

'THE ENGINEER' BUYERS GUIDE Published annually. One FREE copy is sent to all direct postal subscribers on publication and delivered by newsagents to all regular readers. Additional copies are obtainable at 7s. 6d. each. Postage 1s. 9d. extra.

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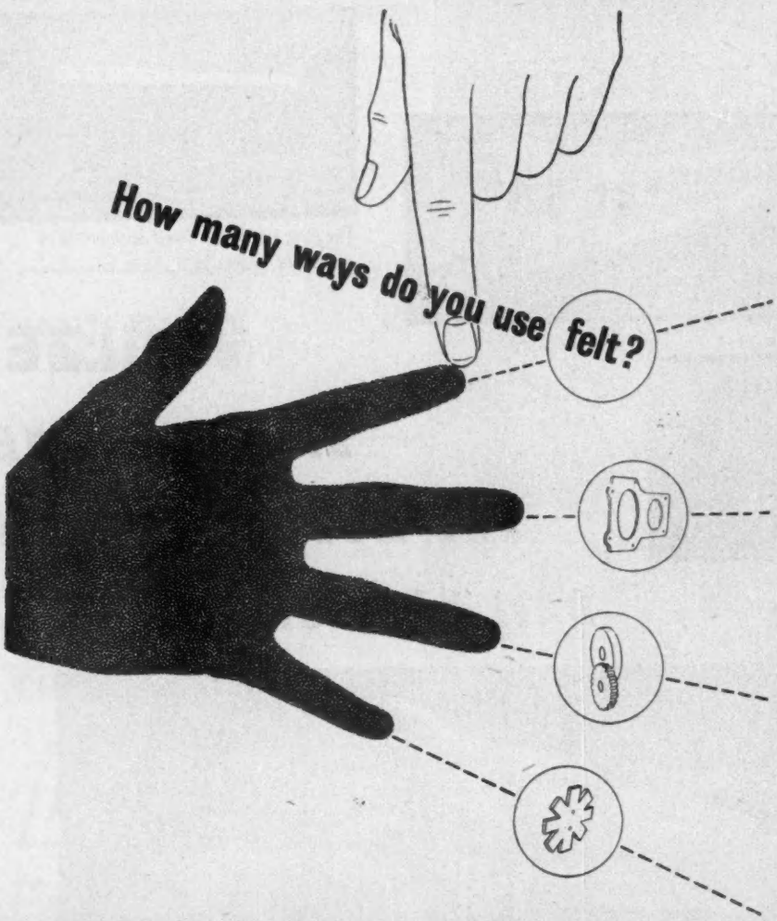

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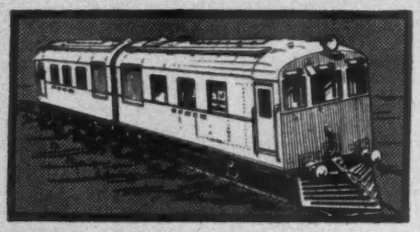

A 1700 H.P. South American Locomotive with over a million and a half miles service to date.

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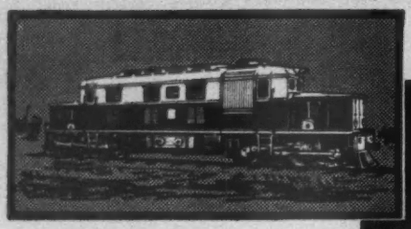
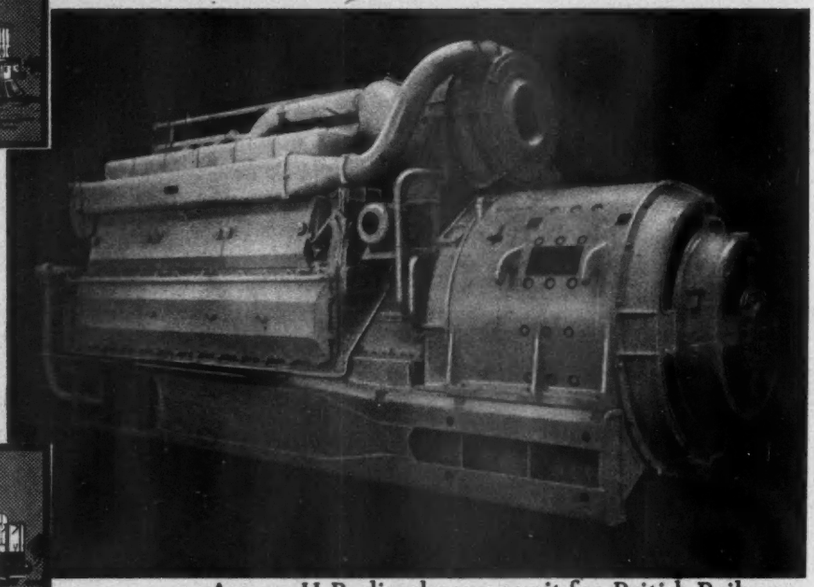


A 735 H.P. unit in operation at 14,000 feet in Bolivia.



A 2300 H.P. diesel power unit for British Railways

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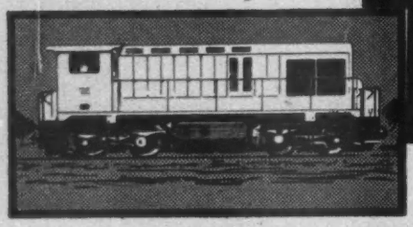
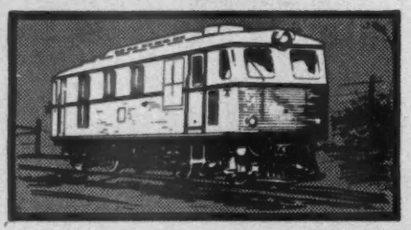
A 850 H.P. diesel-hydraulic Locomotive in French West Africa.





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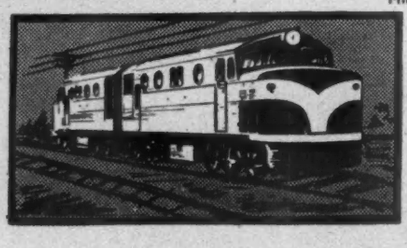
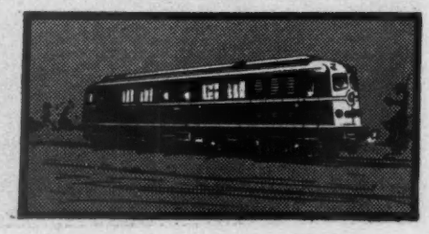


Two 955 H.P. light-weight units in the Australian desert.



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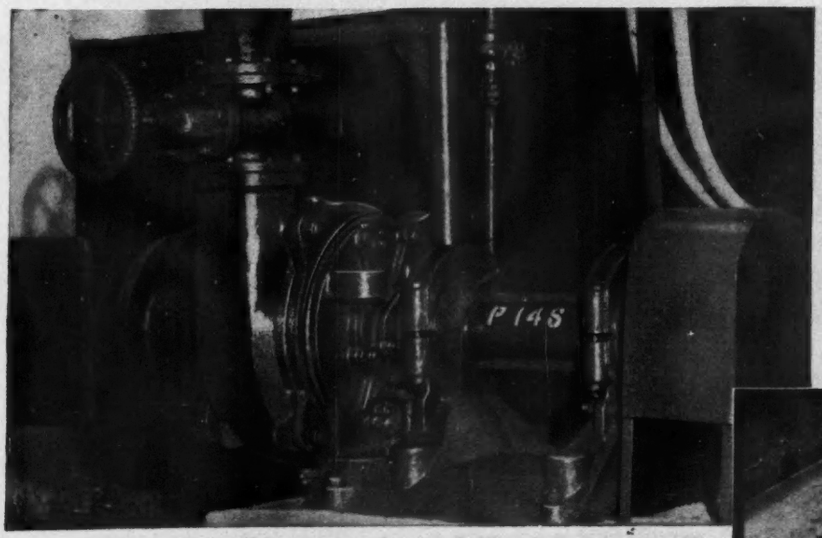
Turbine Bedplates during construction showing internal ribbing, etc. Total finished weight approx. 7 tons.

Photograph by courtesy of C. A. Parsons & Co., Ltd., Newcastle-on-Tyne.

AT BOWATERS MERSEY PAPER MILLS...

LINATEX takes the 'wurry' out of slurry



For *five* years now Bowaters have experienced trouble free service from *three* 3" *LINATEX* pumps handling china clay slurry.

Long-life Linatex—95% pure natural rubber—tough and abrasion-resistant, is the secret behind the success of these pumps.

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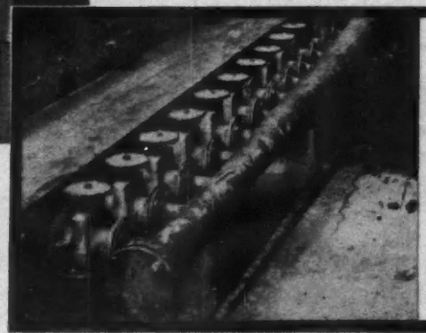

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SUPERLOOP

(Patent pending)

a slimmer, safer mechanical splice

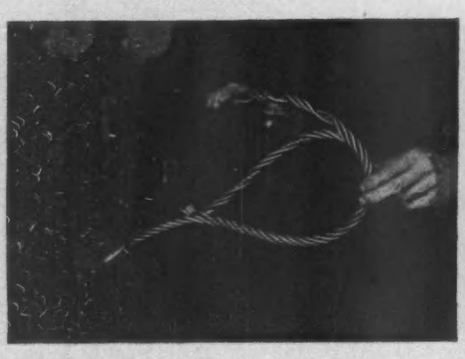
The construction of the Superloop is fully explained in our Brochure— If you are a user of slings —send for this book.

British Ropes Limited have evolved a new type of wire rope sleeve to overcome the drawbacks of other mechanical splices.

The main advantages of this new process, SUPERLOOP, are a safer mechanical splice, a slimmer sleeve and a *true centre pull*. The sleeve, made of a specially approved steel, is closed over the tails of a Flemish Eye splice making SUPERLOOP the lightest, slimmest and easiest to handle. It is at least as strong as a well made hand splice, and practical tests show it to be particularly ideal for the hard-worked sling. The smooth exterior of the sleeve and its small dimensions mean that SUPERLOOP can be employed in many applications where more bulky hand and mechanical splices are impracticable. SUPERLOOP is concentric with the rope because of the Flemish Eye which is incorporated. A specially developed fitting, known as a SUPERLOOP STIRRUP, is available to protect the bearing of the eye from wear.

The development of SUPERLOOP was achieved only by intensive research and exhaustive tests backed by the wide knowledge and experience of the manufacturers.

SUPERLOOP in conjunction with Blue Strand Preformed Rope gives you the perfect sling.

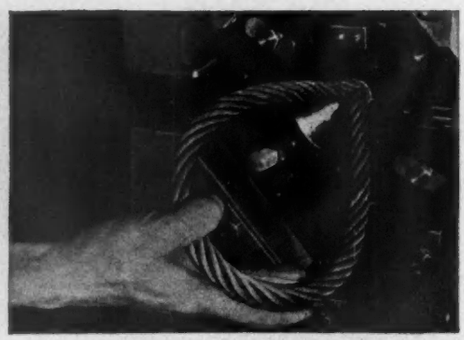


FORMING THE LOOP

The secret of SUPERLOOP's true centre pull —a Flemish Eye is hand spliced and this alone gives a strength in excess of the Safe Working Load even before the sleeve is fitted.

FITTING THE SLEEVE

The steel sleeve is fitted neatly over the tails of the splice and is tapped into place entirely covering the wire ends.



PRESS CLOSES THE SLEEVE

Specially designed Dies permit comparatively low pressures to be used, eliminating any serious damage due to crushing.

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(Patent pending)

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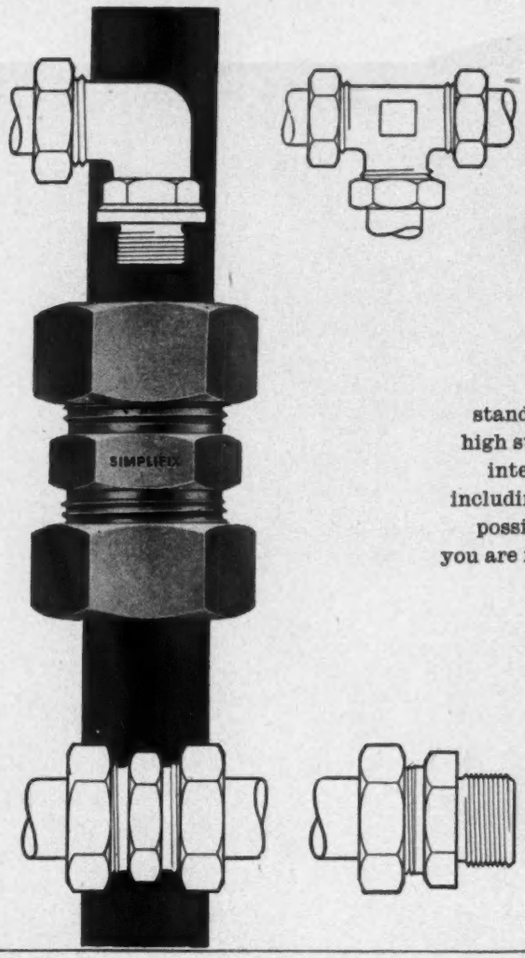

Simplifix pipe couplings are interchangeable

For assembling pipe line systems quickly and easily, use standardised Simplifix couplings. Made to B.S.S. 2051 Part I, their high standard of dimensional accuracy ensures that all fittings are interchangeable. They can be used on almost any kind of tubing, including those with very thin walls, and are available in the widest possible variations of standard and non-standard fittings. In brief you are most likely to find *your* requirements in the Simplifix range. Our illustrated catalogue gladly sent on request.

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"But why can't they use my magnet?"

"Well, you see Johnny, it's because *your* sort of magnet can't be switched 'on and off'!"

"Huh! I wouldn't like mine to do that!"

"I know, but then you don't use yours to control water or gas and things."

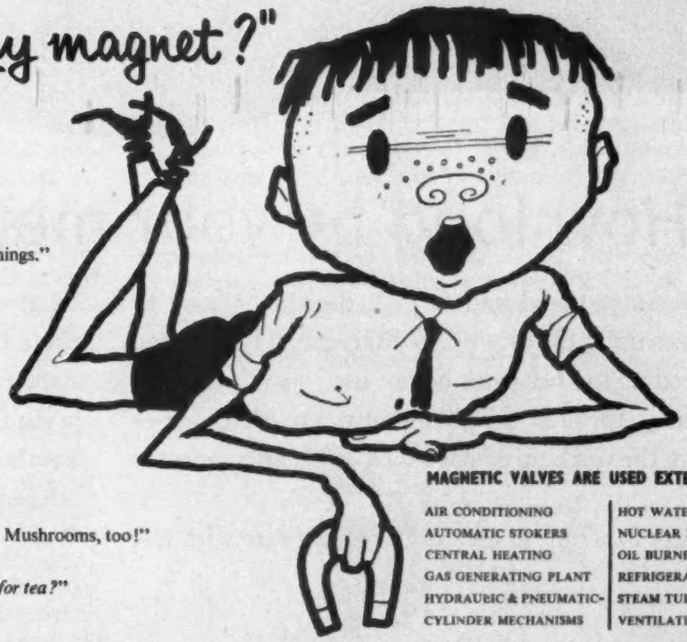
"Control water or gas? Seems stupid to me—why can't they use a tap like Mum does?"

"Ah! But using a tap means that you rely on what's called the 'human element'. That's why these valves are fitted to do things automatically—without people being involved."

"Mr. Stevens told me they make chocolates with them!"

That's right, but not exactly to *make* chocolates, to *help* make them. Mushrooms, too!"

Cor! I like mushrooms." (Throwing away magnet) "Can I have some for tea?"



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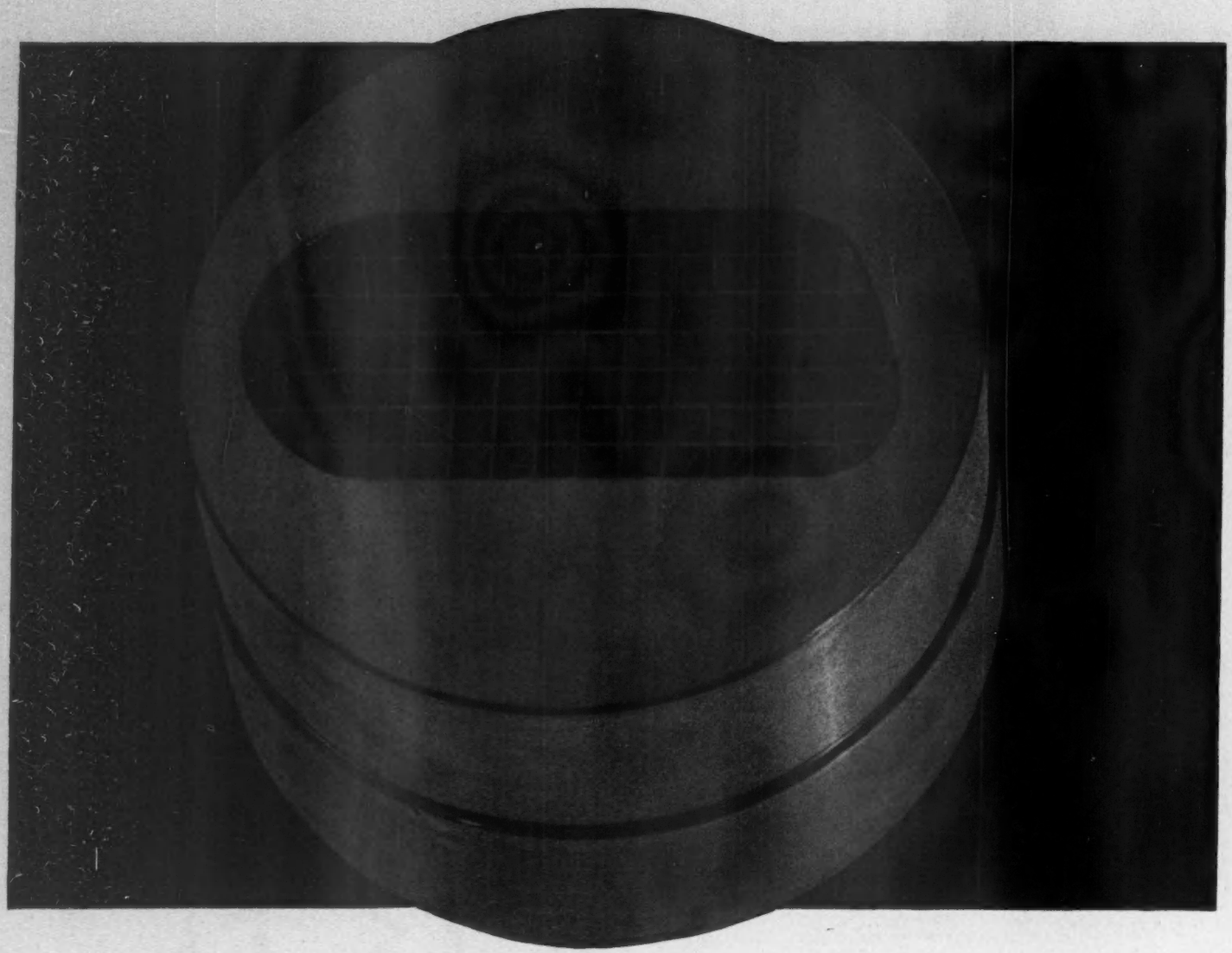

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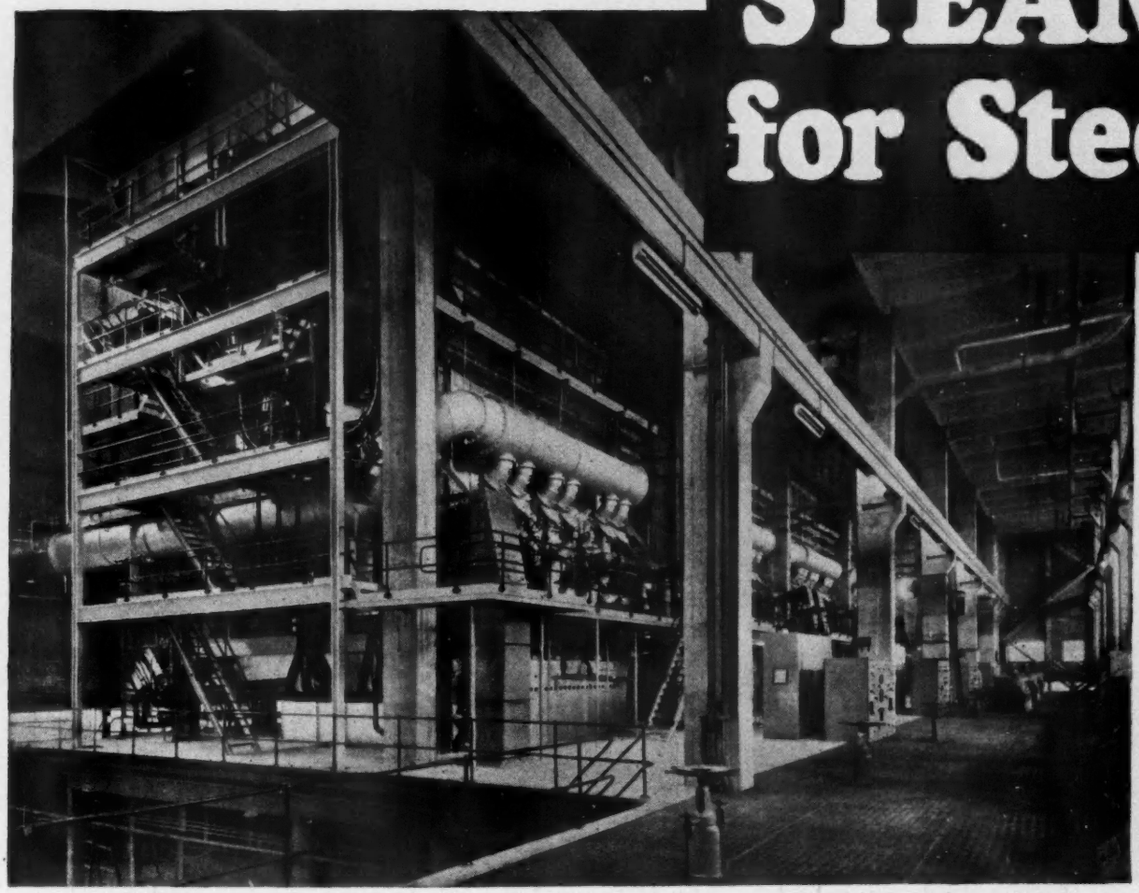

BABCOCK & WILCOX Ltd. are proud to have had an important part in the equipment of the new Colvilles £20,000,000 coke oven, blast furnace and steel-making plant at Ravenscraig, Motherwell, Scotland.

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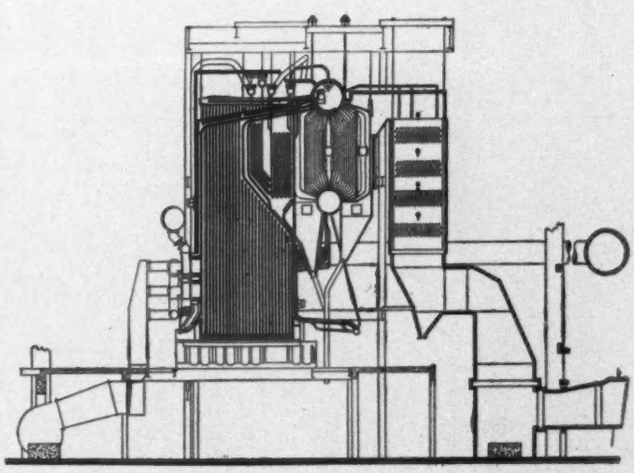

Sectional arrangement of one of the 125,000 lb. / hr. Babcock Bi-drum boilers at the Ravenscraig works.

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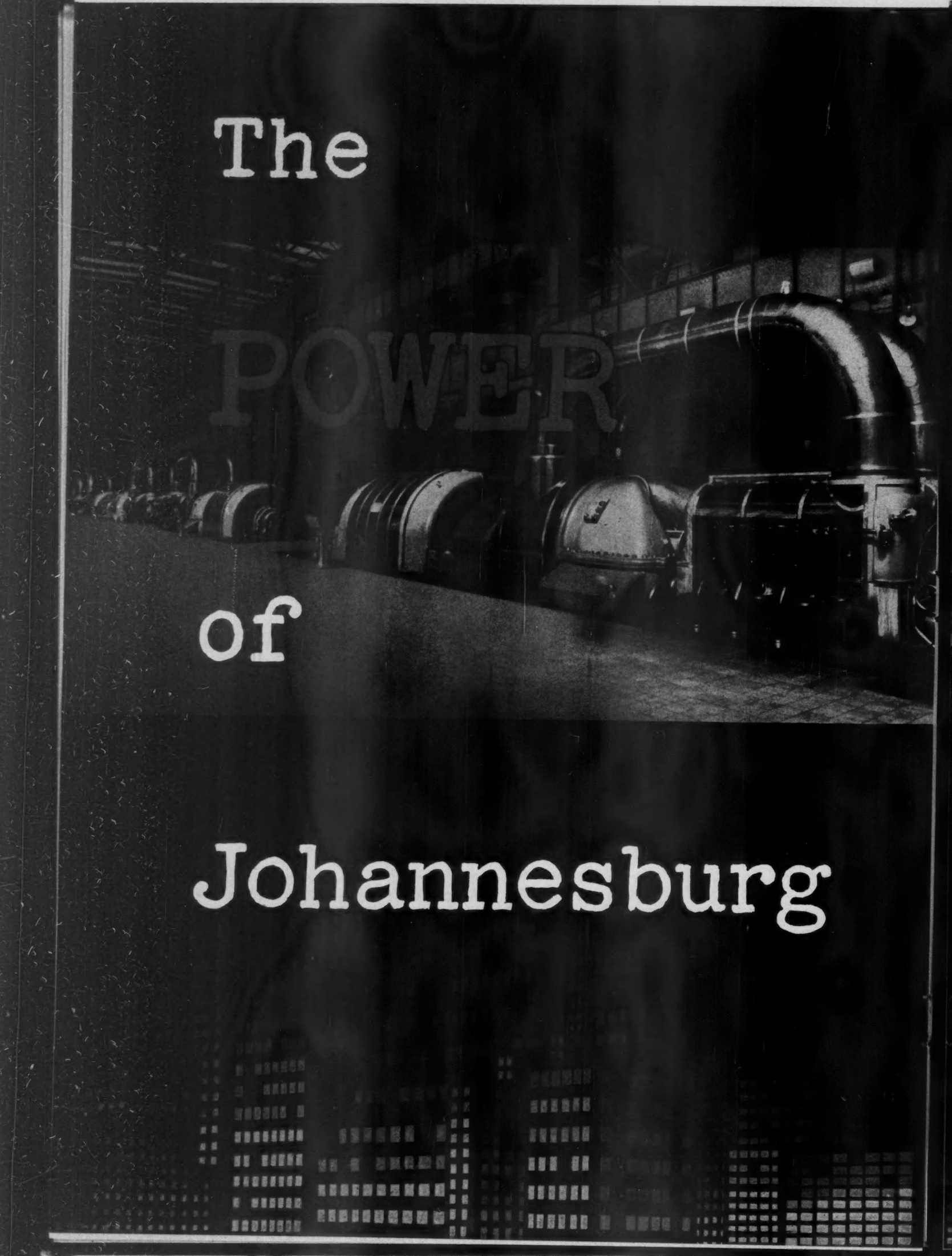
B

The POWER of Johannesburg



Johannesburg, Transvaal! At night a fairyland of light, by day a bustling centre of commerce. A busy city, a modern city, a city powered by the G.E.C.

With the latest contract for two 30 MW turbo-generators, the number of G.E.C. sets in Johannesburg's four power stations will total twenty five and will provide three quarters of a million kilowatts. And so the G.E.C. serves Johannesburg with the power to keep a great city alive. A big job indeed—and just the job for the G.E.C. with its vast experience of electrical generation, distribution and control.

G.E.C.

power generation

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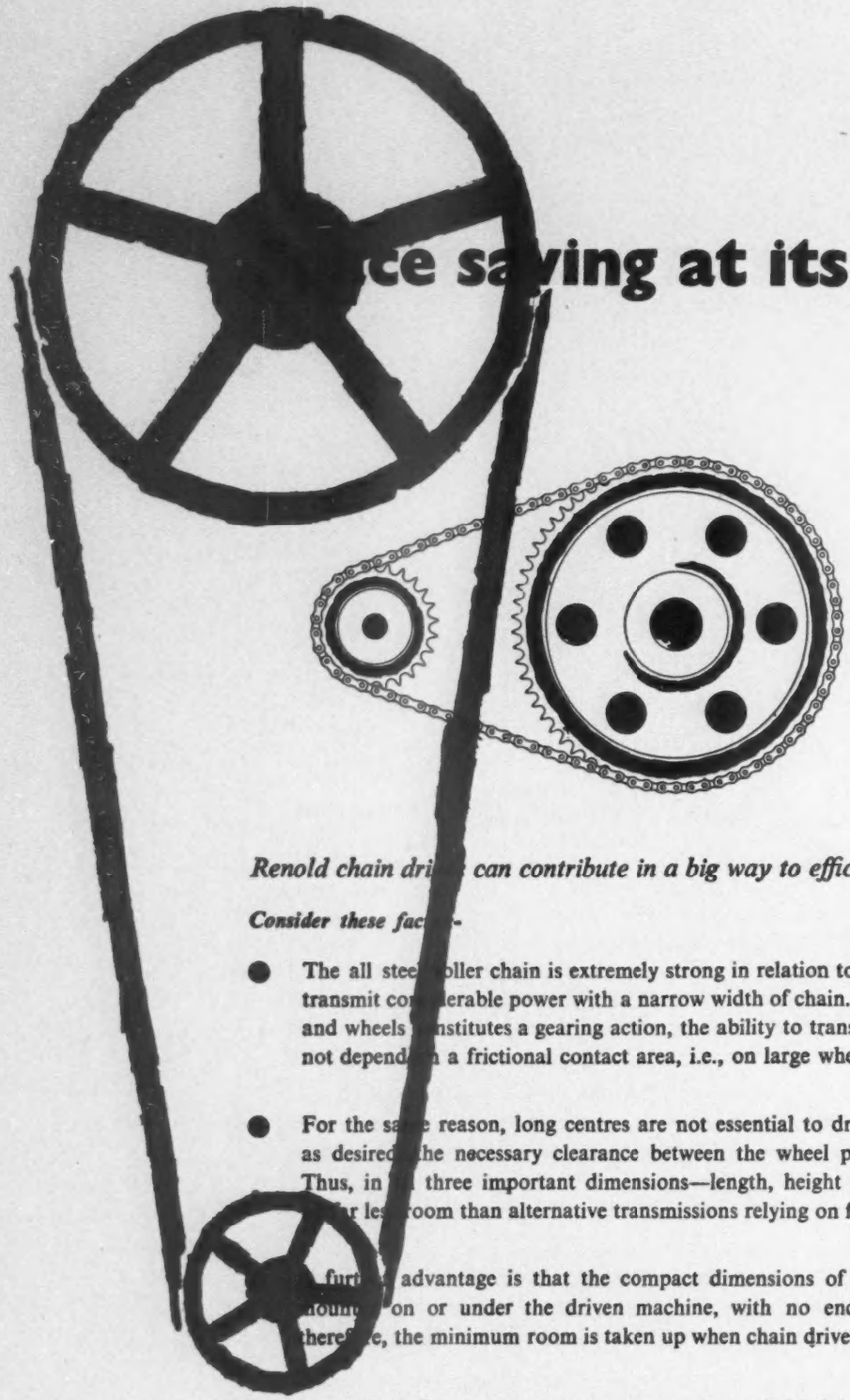

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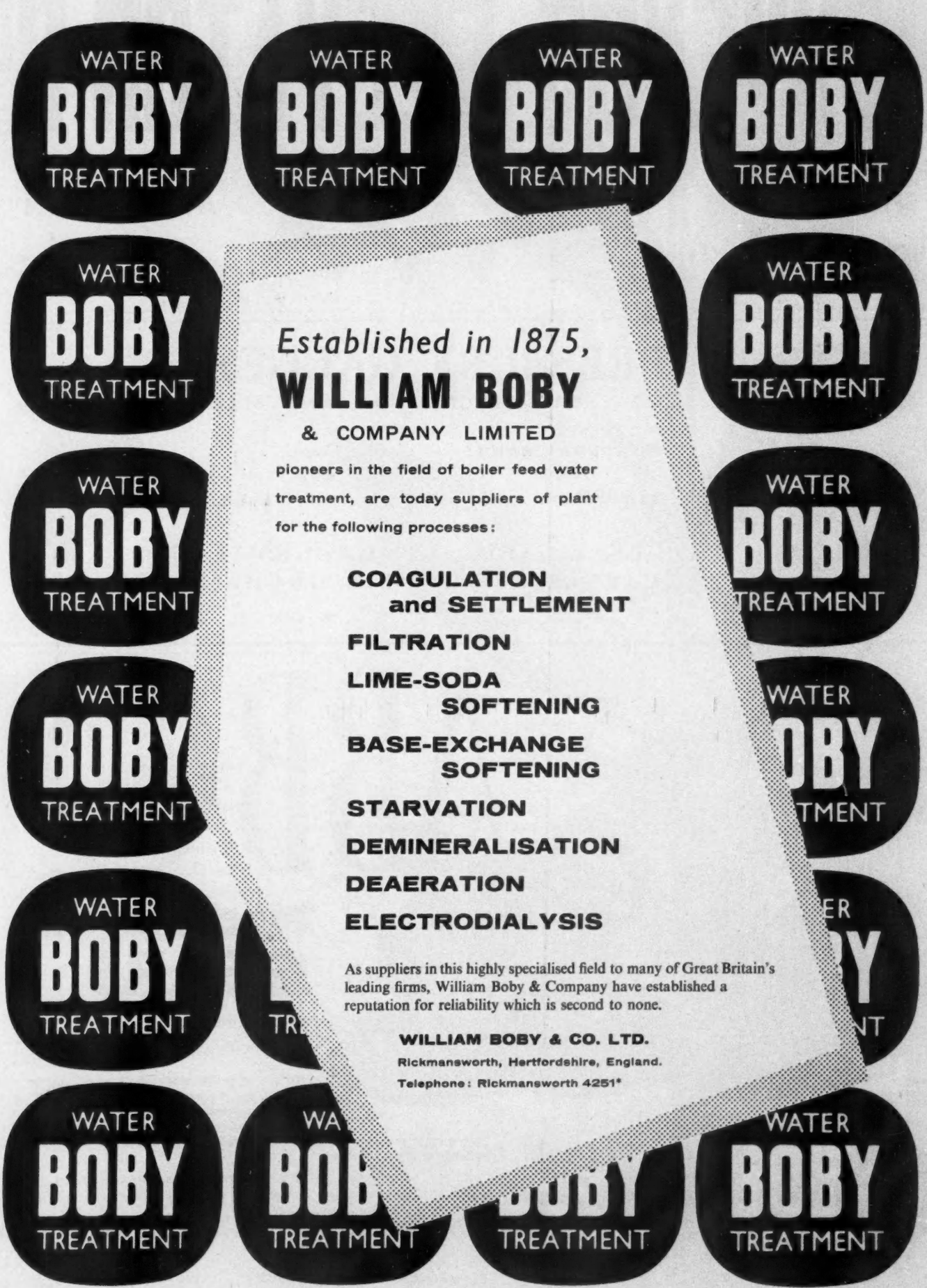
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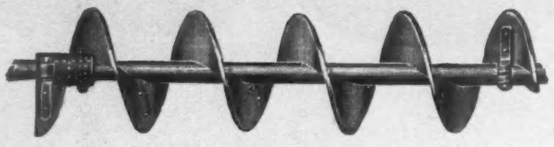

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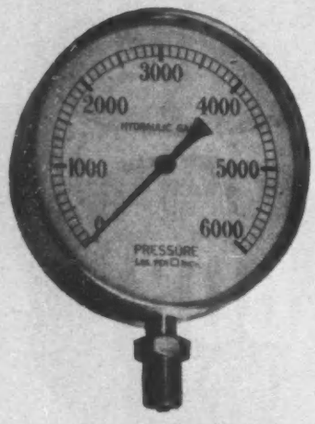

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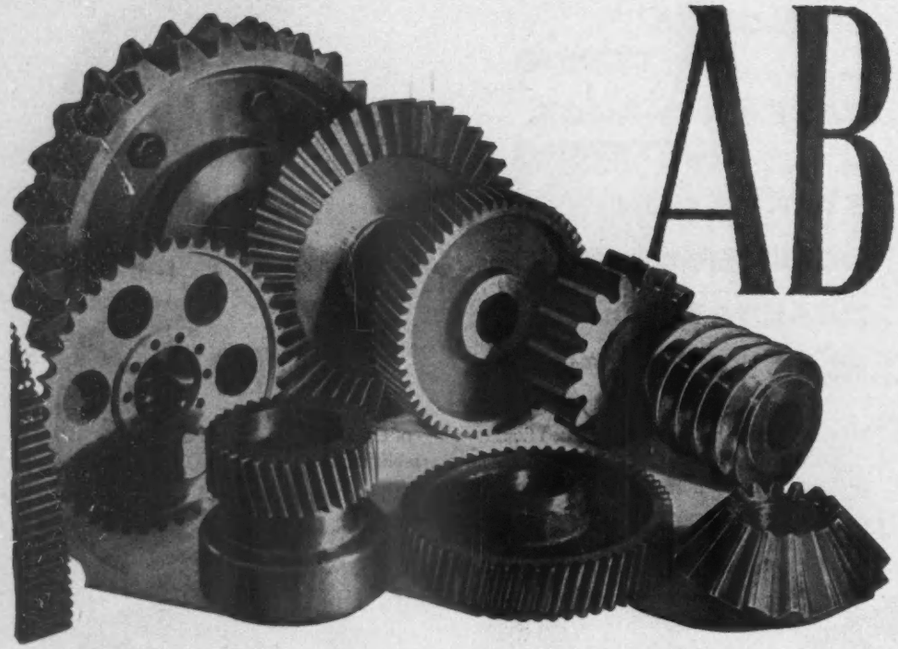

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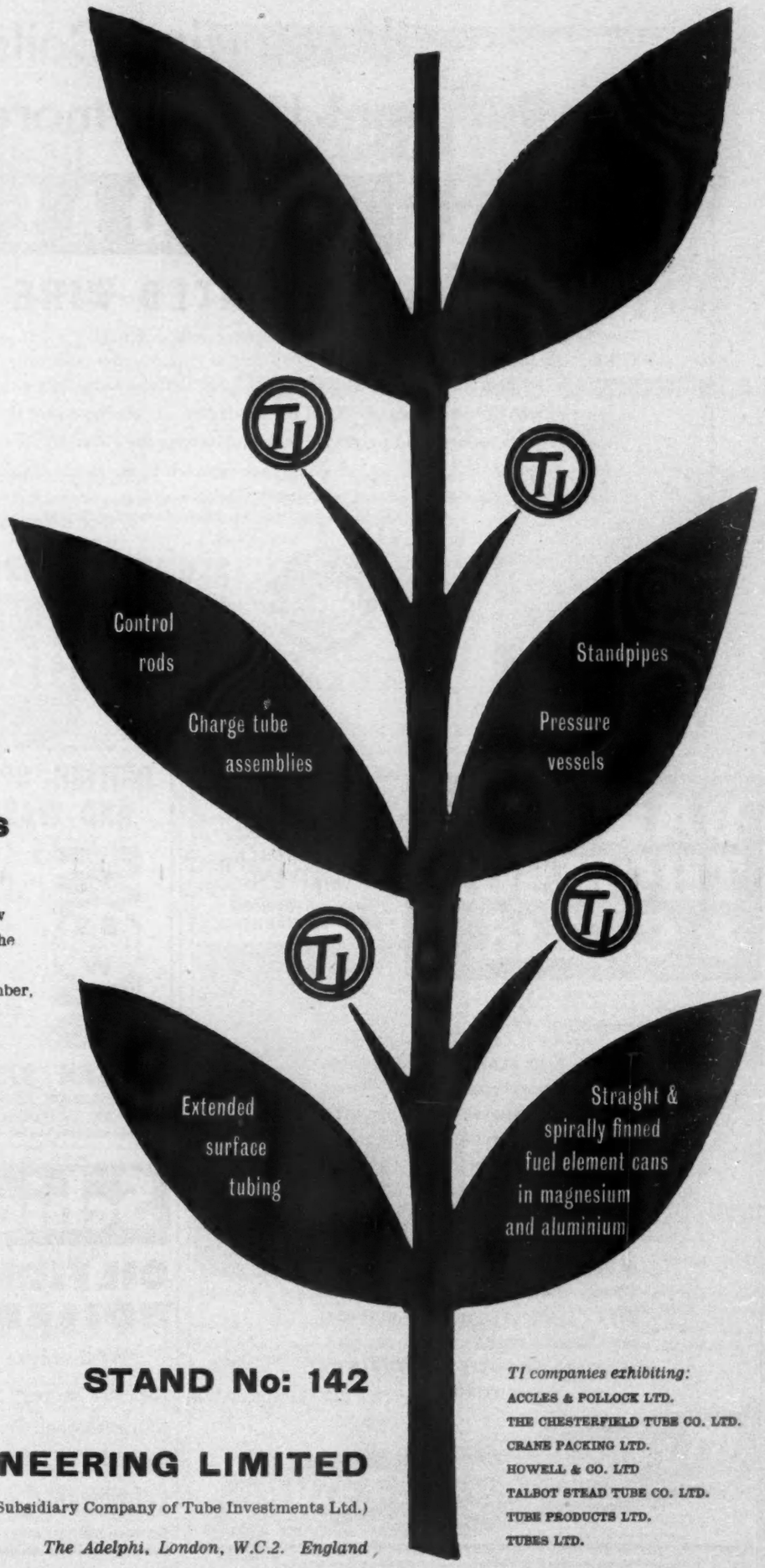

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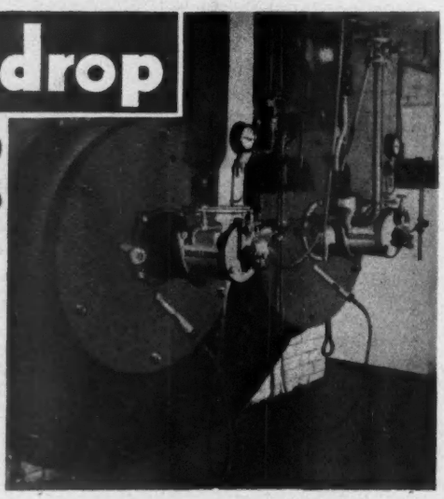

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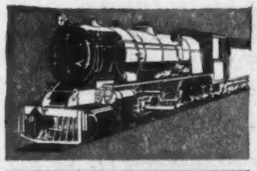

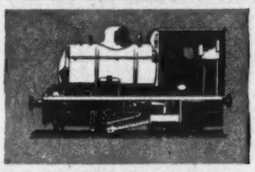

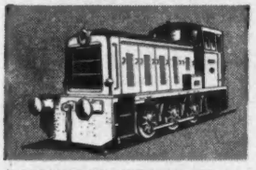

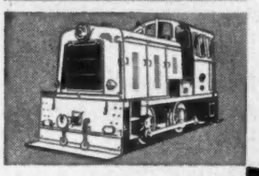

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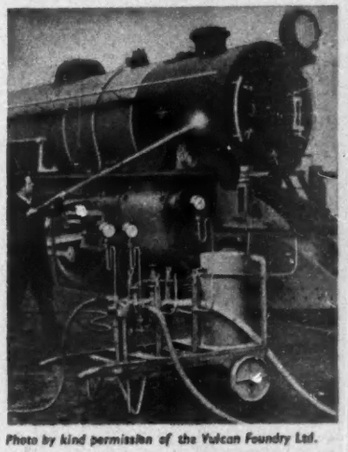

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- (7) No detergents or cleaning solutions are normally necessary.
- (8) No other system offers the same flexibility at low operating costs, low maintenance and low installation costs as the Metcalfe High Pressure Washing Plant.
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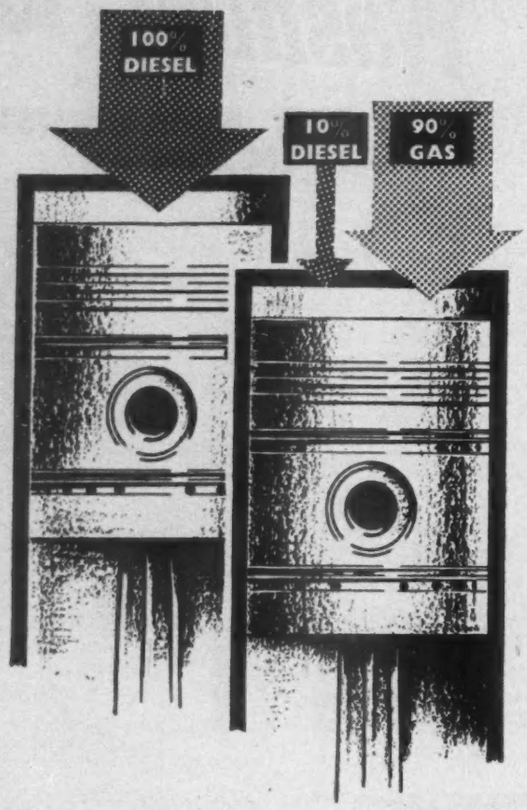

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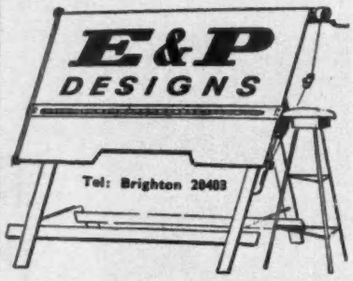

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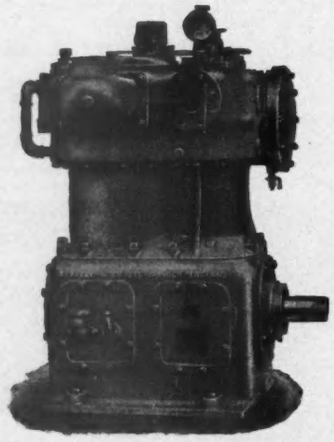

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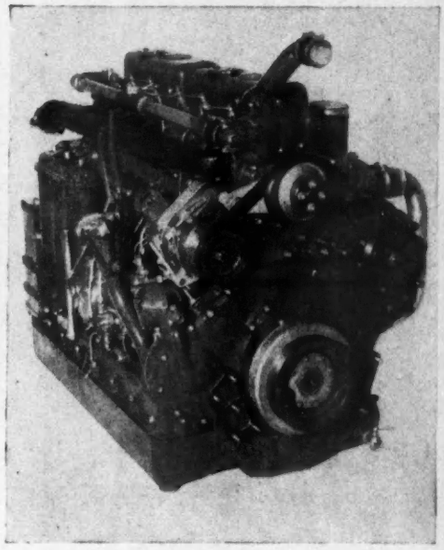
Jet assemblies used in a SPEEDIVAC* Model 203 vapour diffusion pump during a test in which the pump operated for fifteen minutes and then air was admitted for five minutes. The jet assembly in the centre using MS 703 silicone fluid had survived over 1,000 such cycles yet remained clean. The organic fluids in the other assemblies either failed or lost the ability to pump down to a low vacuum.

**Trade name of Edwards High Vacuum Ltd.*



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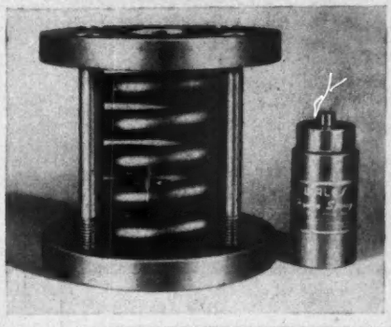

. . . in liquid springs

A steel coil spring and a liquid spring of equivalent performance are shown. The liquid spring contains a silicone fluid which is highly compressible, will show little change in viscosity over a wide temperature range and will not break down even at high temperatures.

You are invited to write for full information about the properties and applications of silicone fluids. Literature on the many other MS silicone products including rubbers, resins, lubricants, compounds, electrical insulants, release and antifoam agents, is also available on request.

MS

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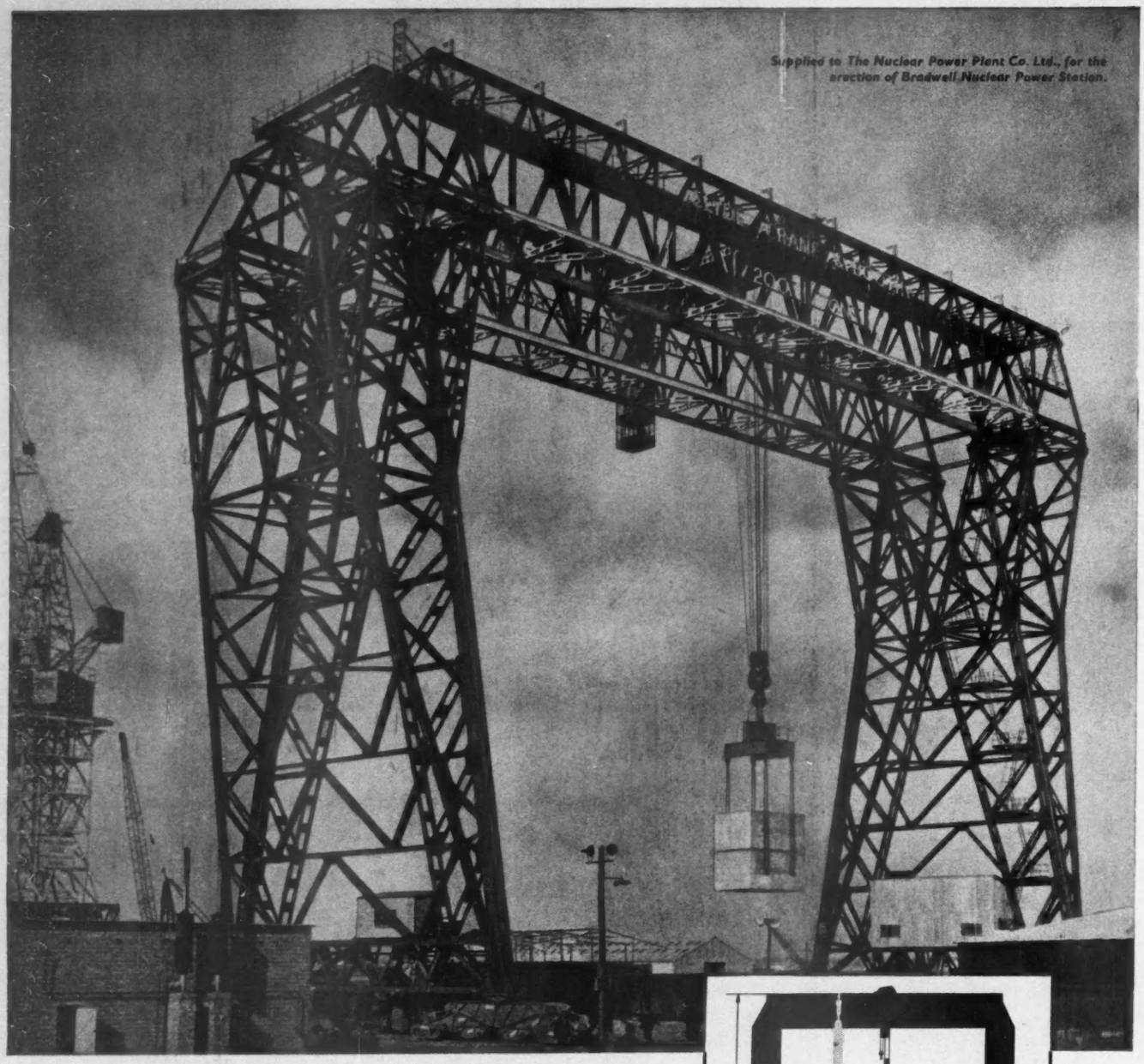

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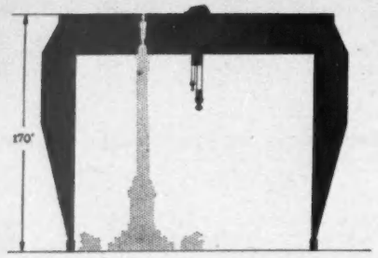

The Booth Goliath showing Nelsons Column on the same scale. Clearance from rail level to underside of bridge is 140'. Distance between rail centres 178'.

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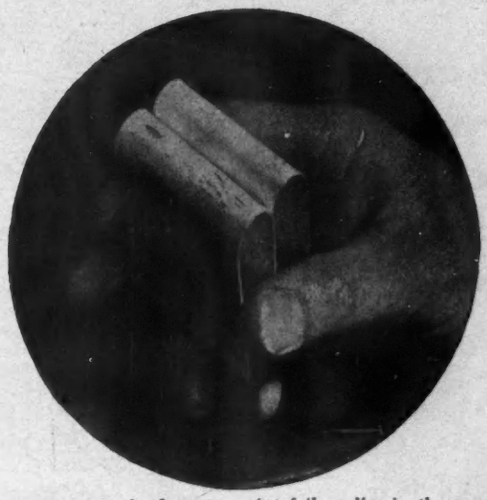

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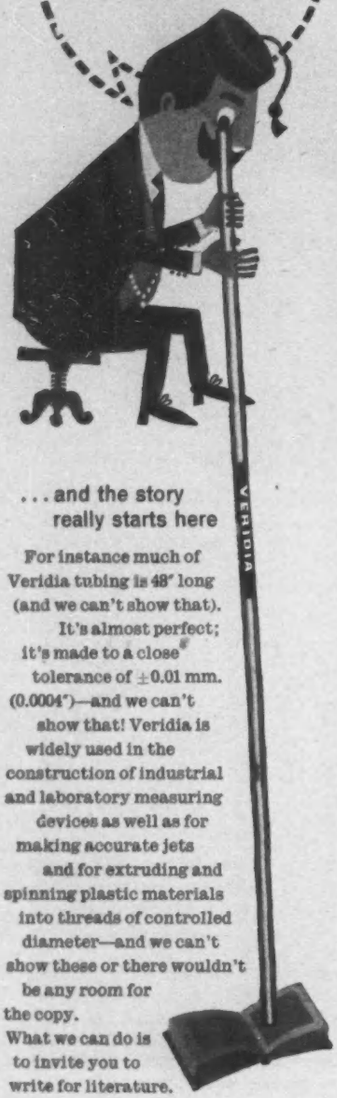

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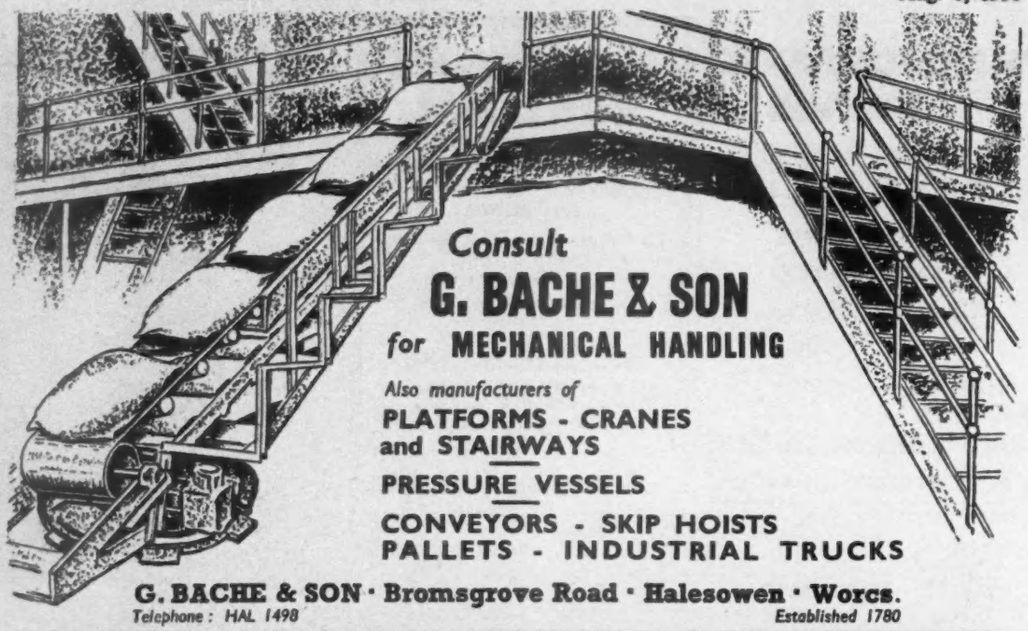

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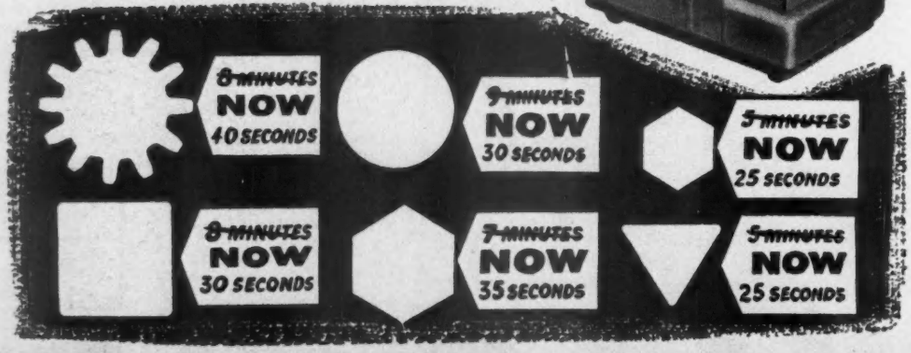
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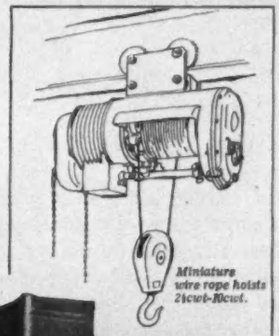
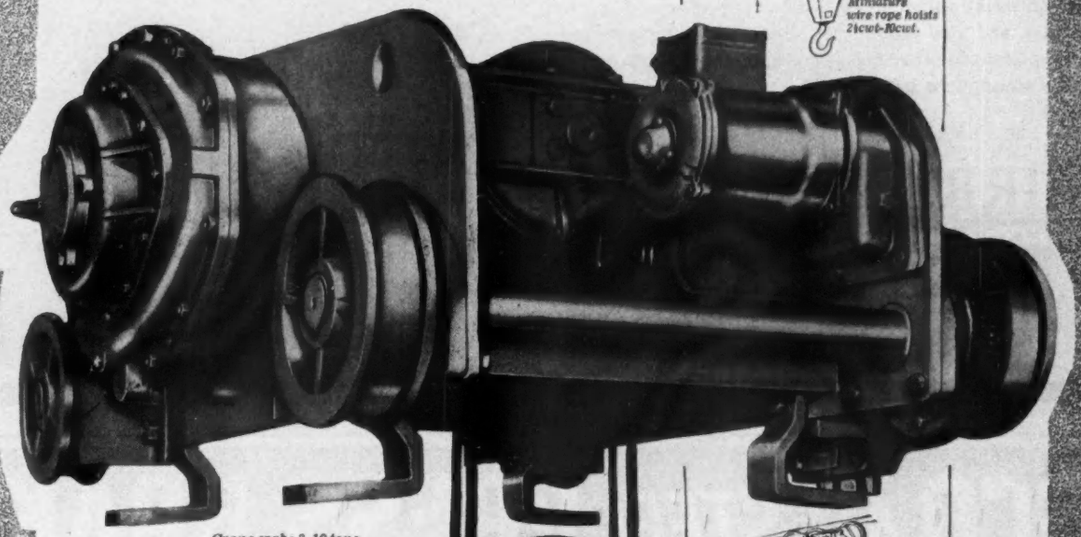
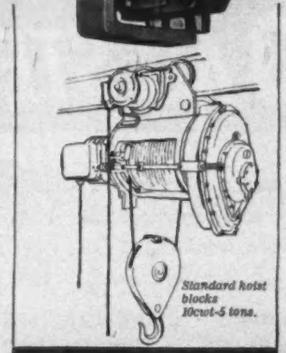


Miniature wire rope hoists 2½cwt-10cwt.



Crane crabs 3–10 tons.



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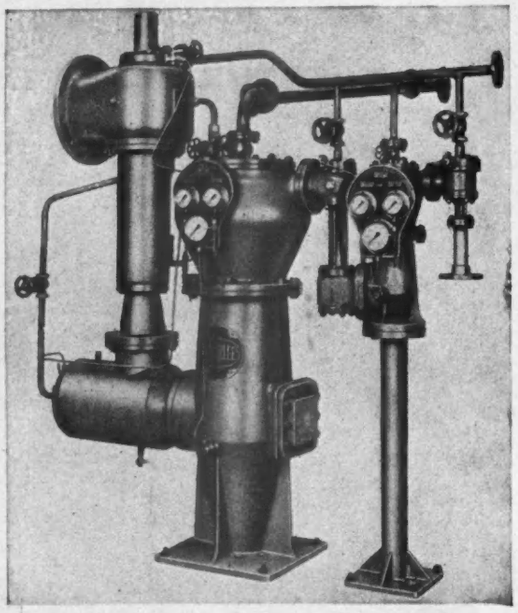

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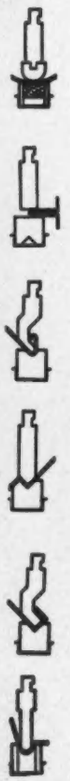

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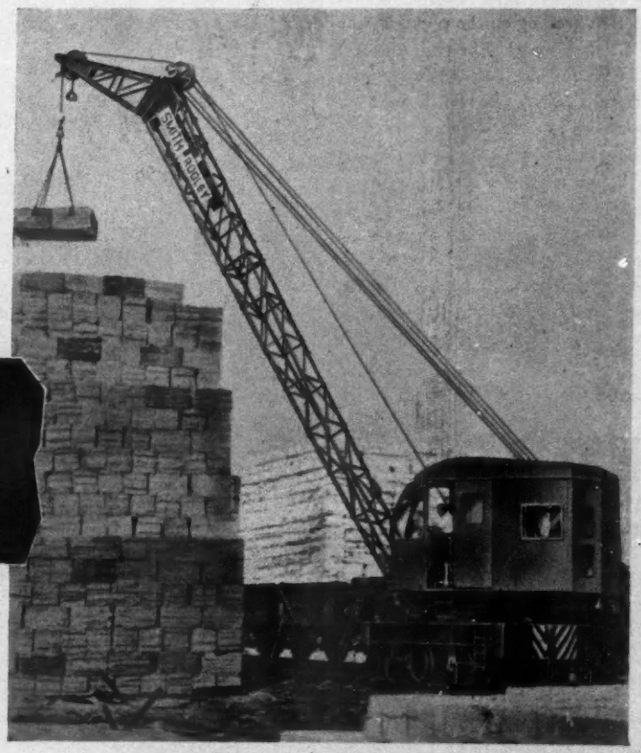

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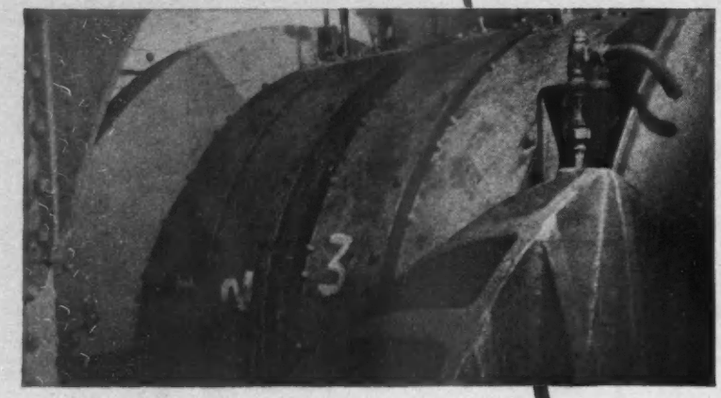

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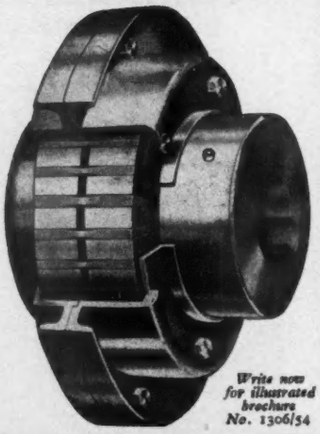

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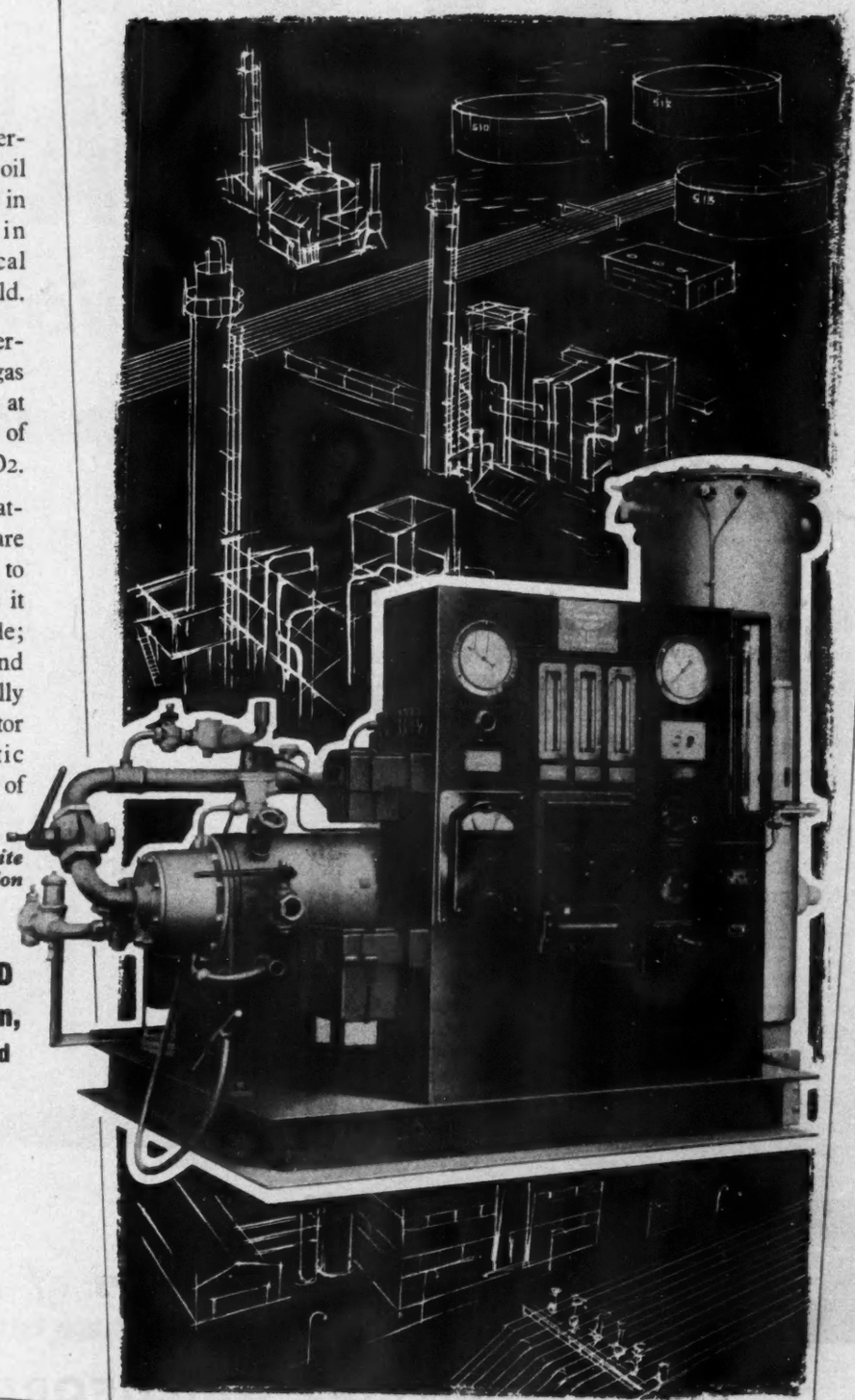

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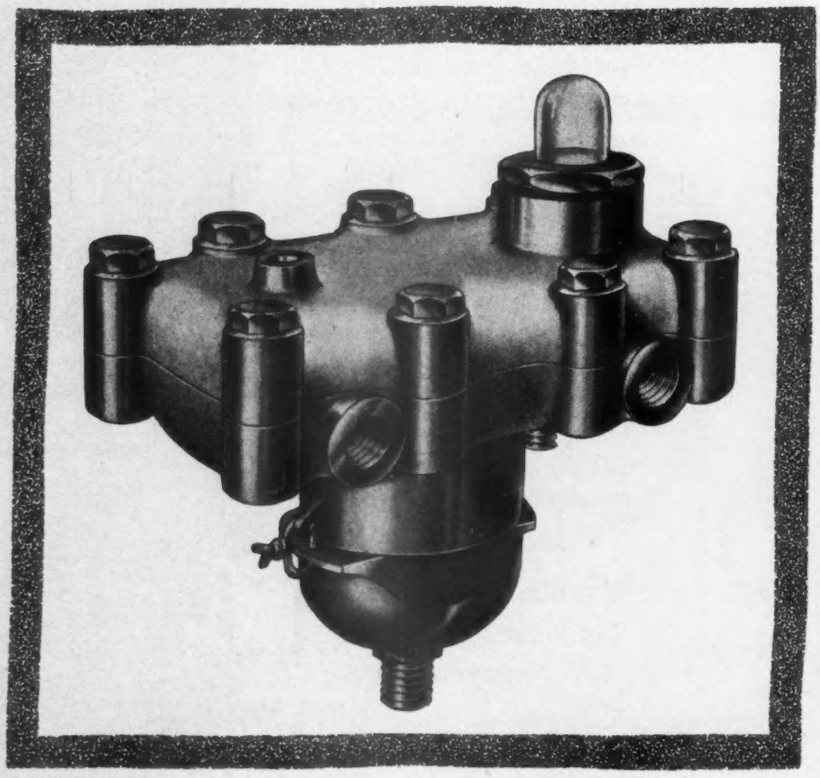

Easily fitted to existing filters, the Vokes Filter Servicing Indicator is an inexpensive, mechanically operated unit. Fitted by copper tubing to the inlet and outlet sides of the filter, it clearly indicates when the filter element is approaching the recommended maximum differential pressure through the collection of contaminants. It can be adjusted and pre-set to operate over a wide range of filter differential pressures and is normally pre-set at the works to suit the application required. Full details of this new Vokes product will gladly be sent on request.

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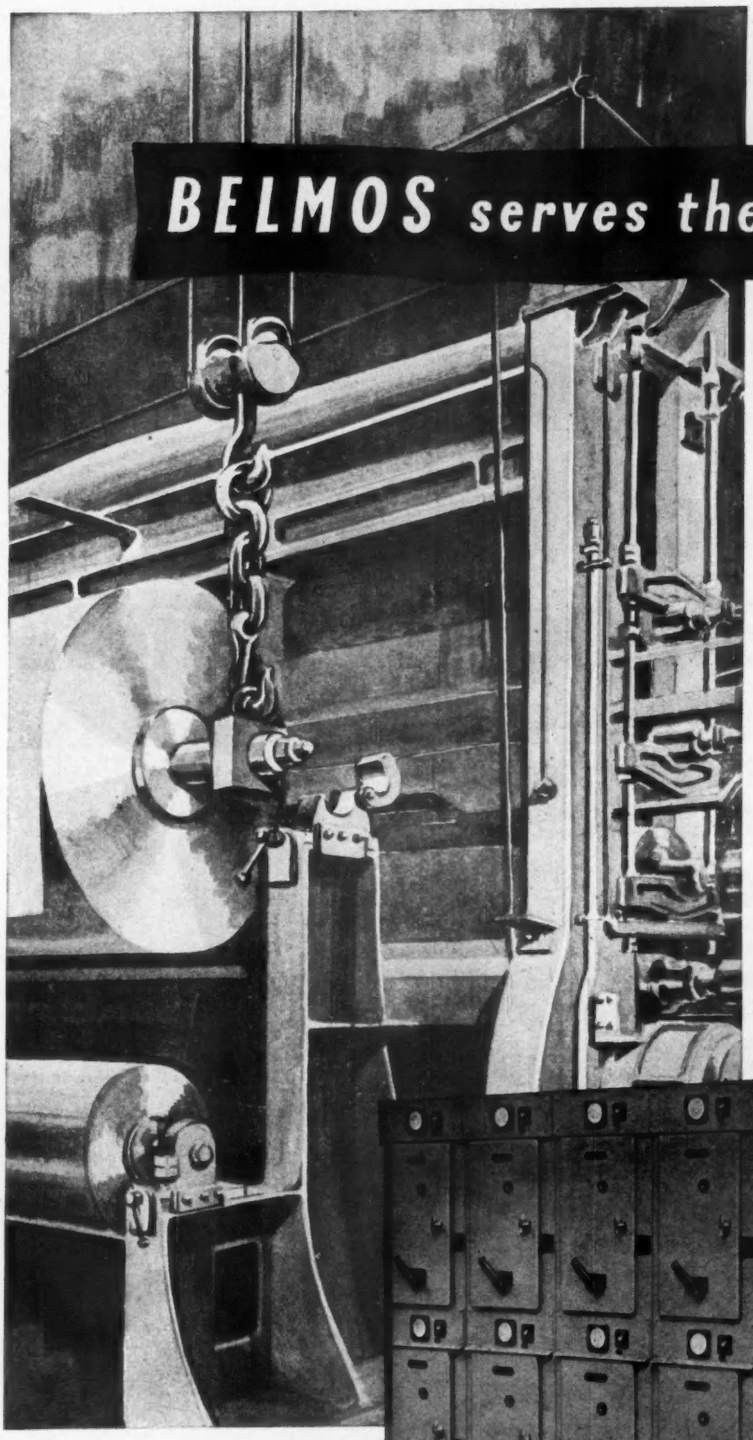

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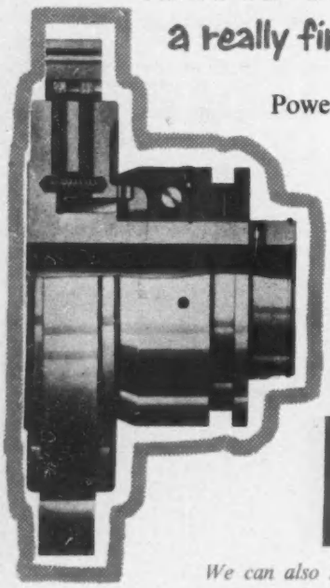

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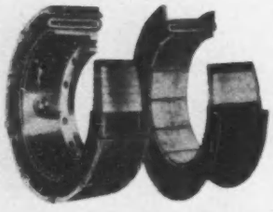

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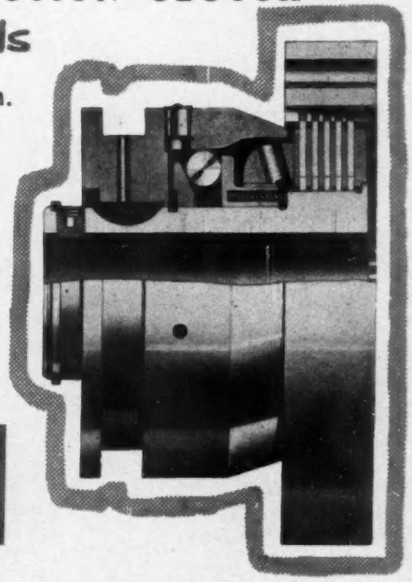

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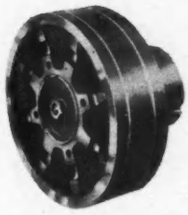

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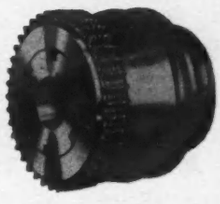

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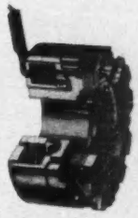

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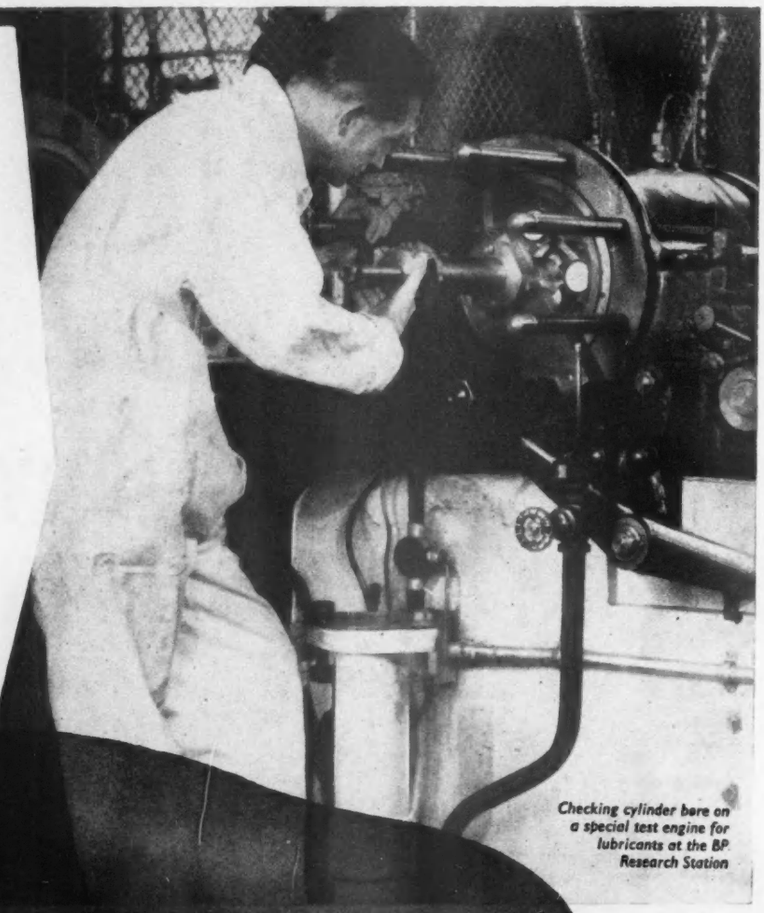

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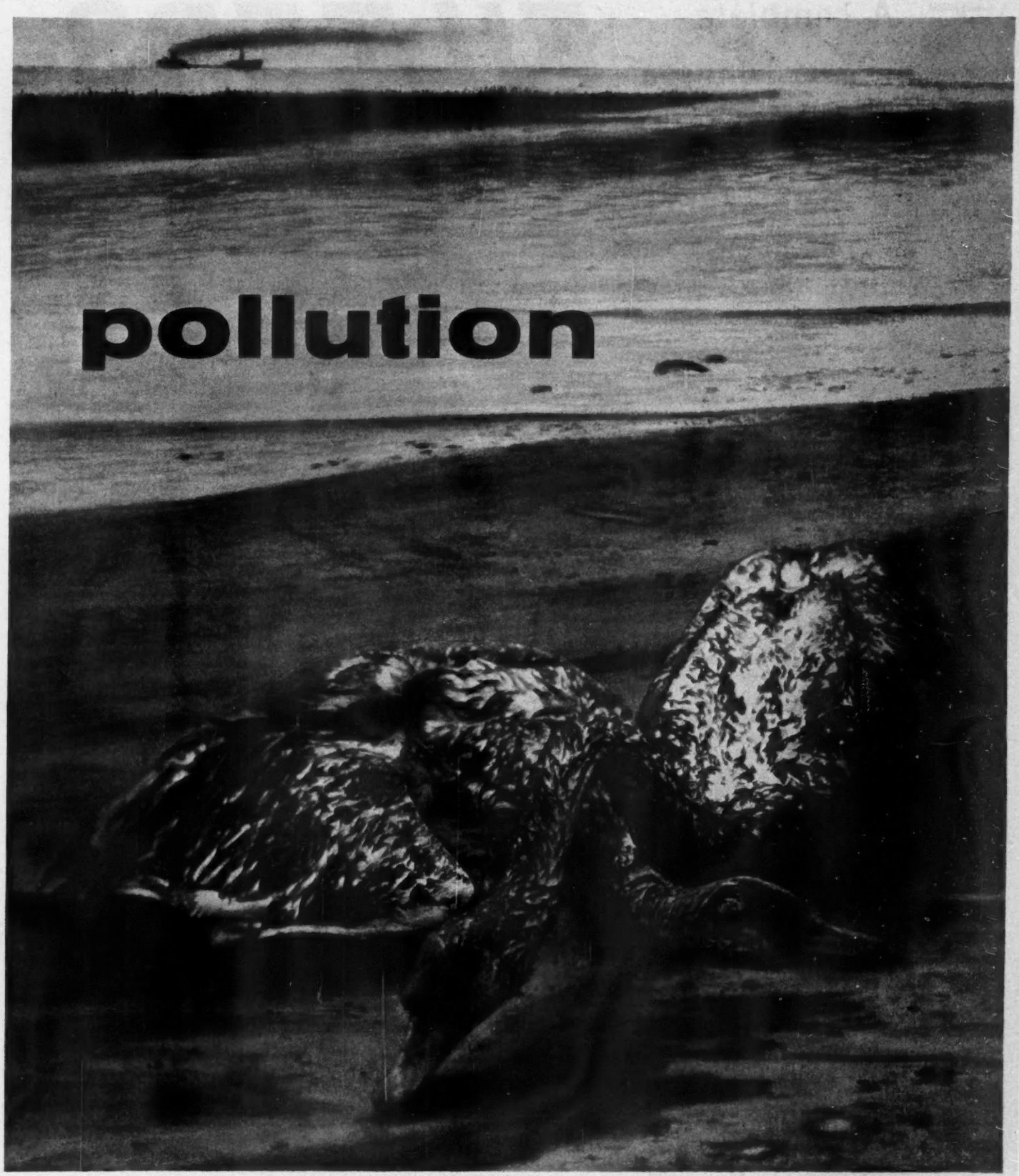

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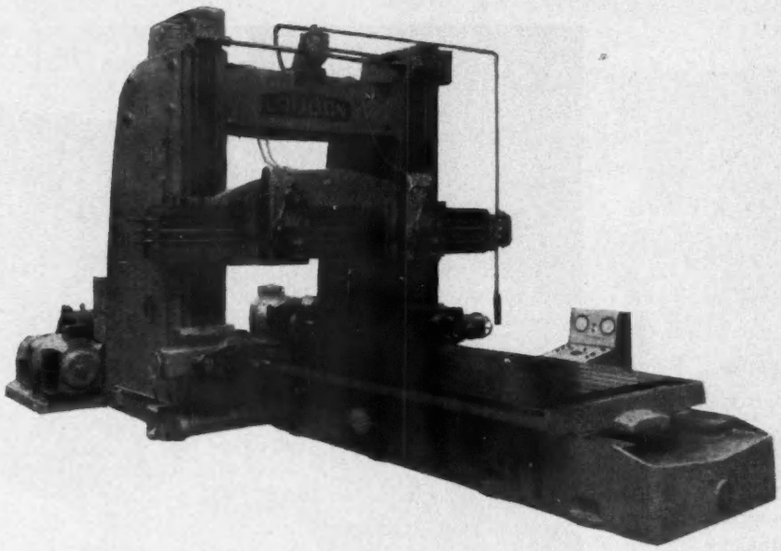

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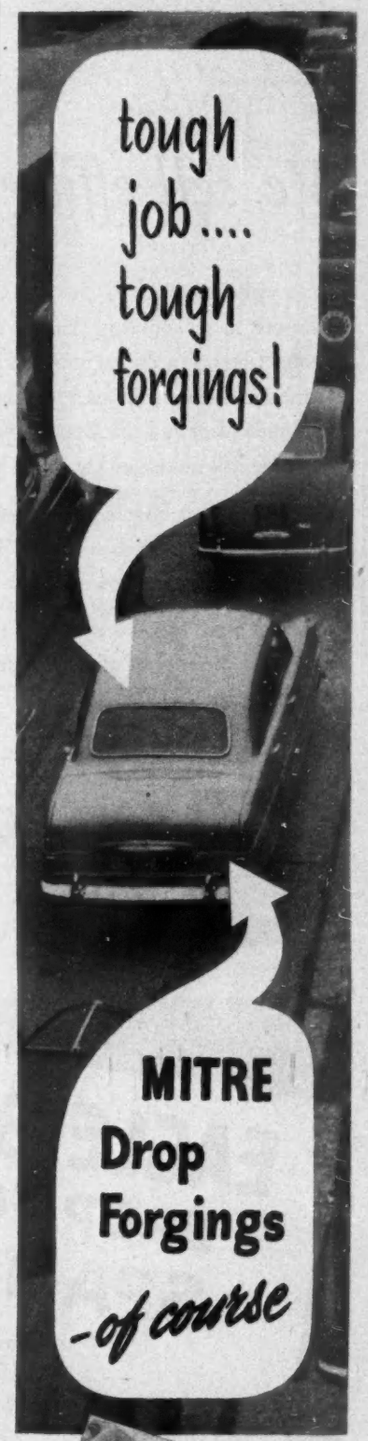

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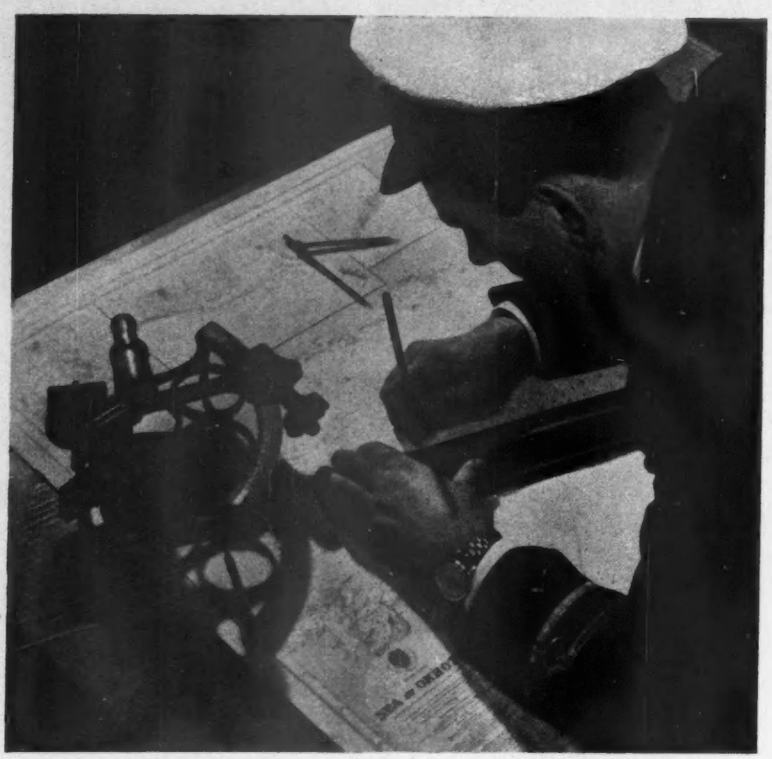

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ESCALATORS

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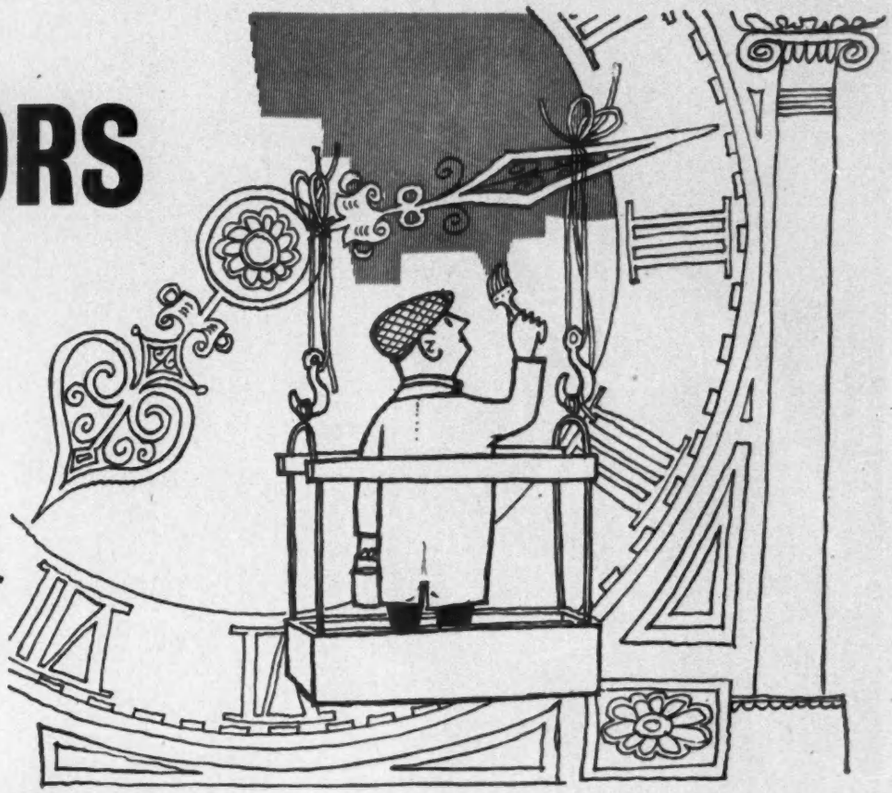

Each of the ten escalators installed for Messrs. Lewis in the Haymarket has a speed on incline of 90 f.p.m. and a carrying capacity of 8,000 persons per hour.

To this picture of cold efficiency must be added the dignified yet charming air created by the soft-glow, dove-grey matt finish of the Formica panels and the polished aluminium-alloy deckings and mouldings.

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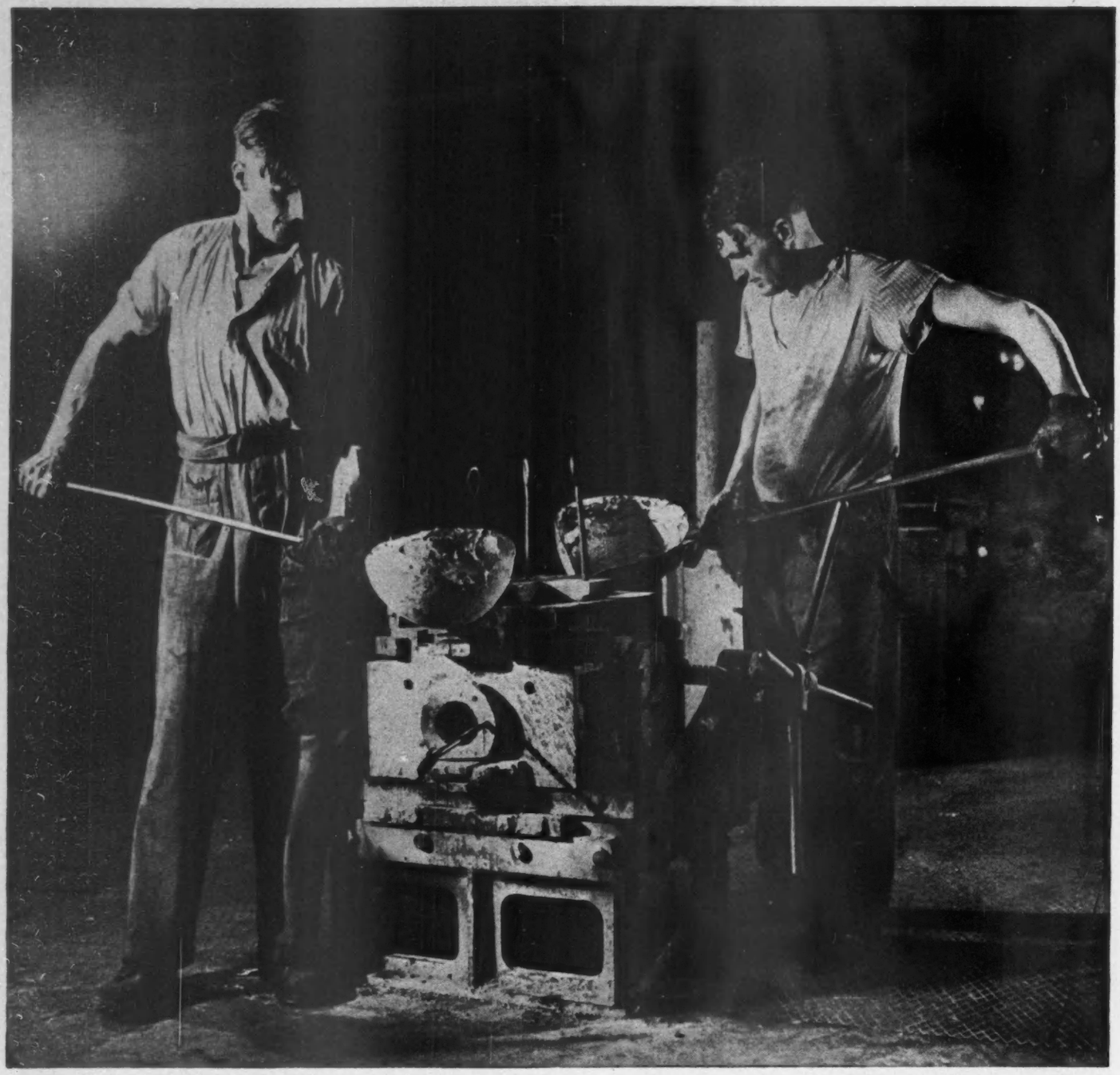
BRANCHES IN MANCHESTER, NEWCASTLE, BIRMINGHAM, BRISTOL and GLASGOW

AP93



Strictly to Specification

The selection of alloy for a given casting is influenced by design and foundry technique as well as by the physical properties required of the casting in service. Close co-operation between designer and founder is therefore desirable to determine the most suitable alloys and this must be effectively supported by regular checks of incoming materials and foundry melts to ensure conformity to specification.

William Mills Limited

FOUNDERS IN ALUMINIUM ALLOYS

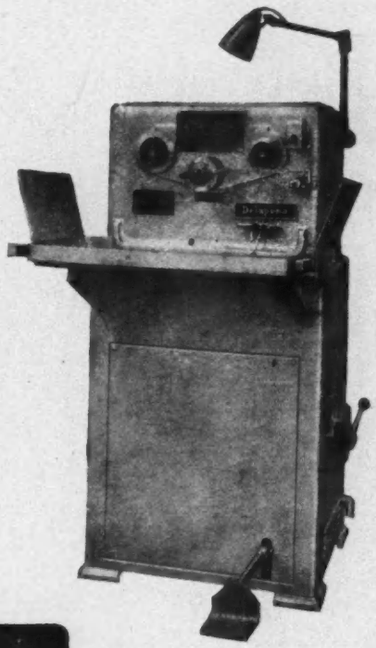
Aluminium gravity die casting used by Ransomes Sims & Jefferies Ltd. in their MG.5 tractor.

SAND CASTINGS GRAVITY DIE CASTINGS PRESSURE DIE CASTINGS | FRIAR PARK FOUNDRY, FRIAR PARK ROAD, WEDNESBURY, STAFFS.

AP118

...a quarter of a tenth of a thou?

This is the Delapena Horizontal Honing Machine Model HHM/1A. It is precision built—for precision operation. If the circumstances are right, it can work to limits as fine as ·000025 of an inch. It is also widely and variously useful in the more normal applications in which limits a little less strict are in force. In correcting errors of taper, ovality and surface finish; in eliminating surface waviness and surface layers; in rectifying bore distortion after hardening, Delapena Equipment earns profit for engineering concerns large and small throughout the world. Semi-skilled personnel can operate Delapena Honing Machines.



HORIZONTAL HONING MACHINES:
For bores from ·120″ to 3·125″ internal diameter and up to 12″ in length.

VERTICAL HONING MACHINES:
For bores from ·375″ to 10″ and up to 36″ in length.

Delapena PRECISION HONING EQUIPMENT

DELAPENA & SON LIMITED
Manufacturers of Induction Heating and Precision Honing Equipment
ZONA WORKS · CHELTENHAM · ENGLAND
Telephone: CHELTENHAM 56341

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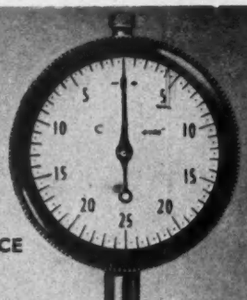
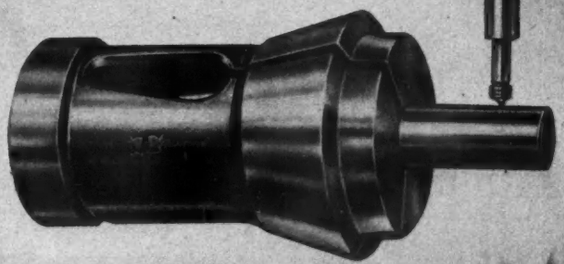
it's true it's Crawfords



CAPSTAN & AUTO COLLETS
GUARANTEED TO ·001″ AT 1″ FROM FACE



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Crawford Collets Ltd.

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MIDLAND STOCKISTS: Rotaslp Engineering Ltd., Vulcan Rd., Industrial Site, Lode Lane, Solihull, Birmingham. *SOLihull 2239*

Agents for South West England and Wales—
Messrs. W. O. Bullock & Sons Ltd., 126 Rodbourne Road, Swindon, Wilts. *Tel.: Swindon 6331*
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..the ideal borehole pump

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BN.215

BERESFORD submersible PUMPS

CORNERCROFT GROUP

James Beresford & Son Limited,
Kitts Green, Birmingham 33. Telephone: STEchford 3081
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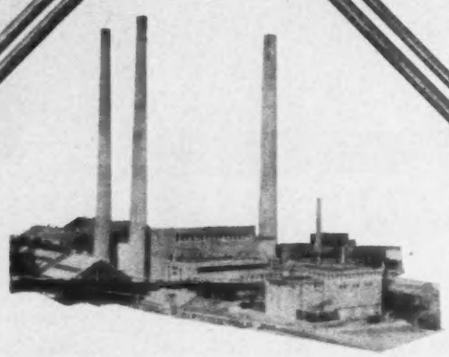
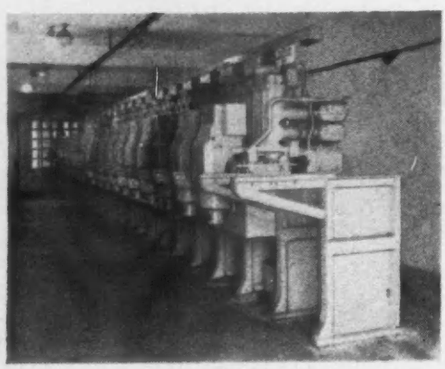
REYROLLE SWITCHGEAR

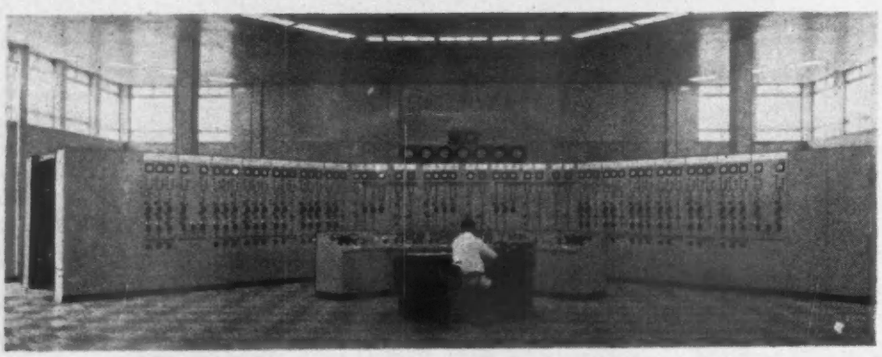
LLANDARCY OIL REFINERY



The illustrations show some of the 11-kV 350-MVA switchgear and the corridor-type control-board supplied by Reyrolle to Llandarcy Oil Refinery

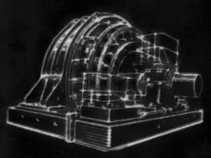
Consulting Engineers
Ewbank & Partners



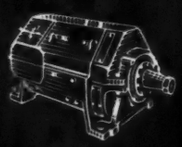


REYROLLE

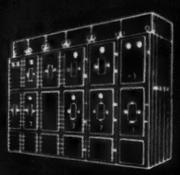
A. REYROLLE & COMPANY LIMITED HEBBURN, COUNTY DURHAM, ENGLAND



PLANT
Rolling Mill Motors for Steelworks



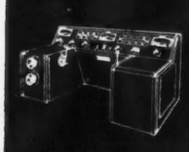
MOTORS
Type MDX motor.



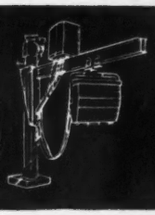
SWITCHGEAR
Type AIR Switchboards

PLANT
Mercury Arc Rectifiers

WELDING
Paradyne arc Welding sets



CONTROL GEAR
Desks & Contactor Boards for Centralised Control



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For all industrial applications.

IN STEELWORKS as in every sphere of Industry, Metropolitan-Vickers are in the forefront of Electrical progress. Many advances in the design of drives and controls for use in steelworks, owe their origin to the research, enterprise and experience of this great organisation

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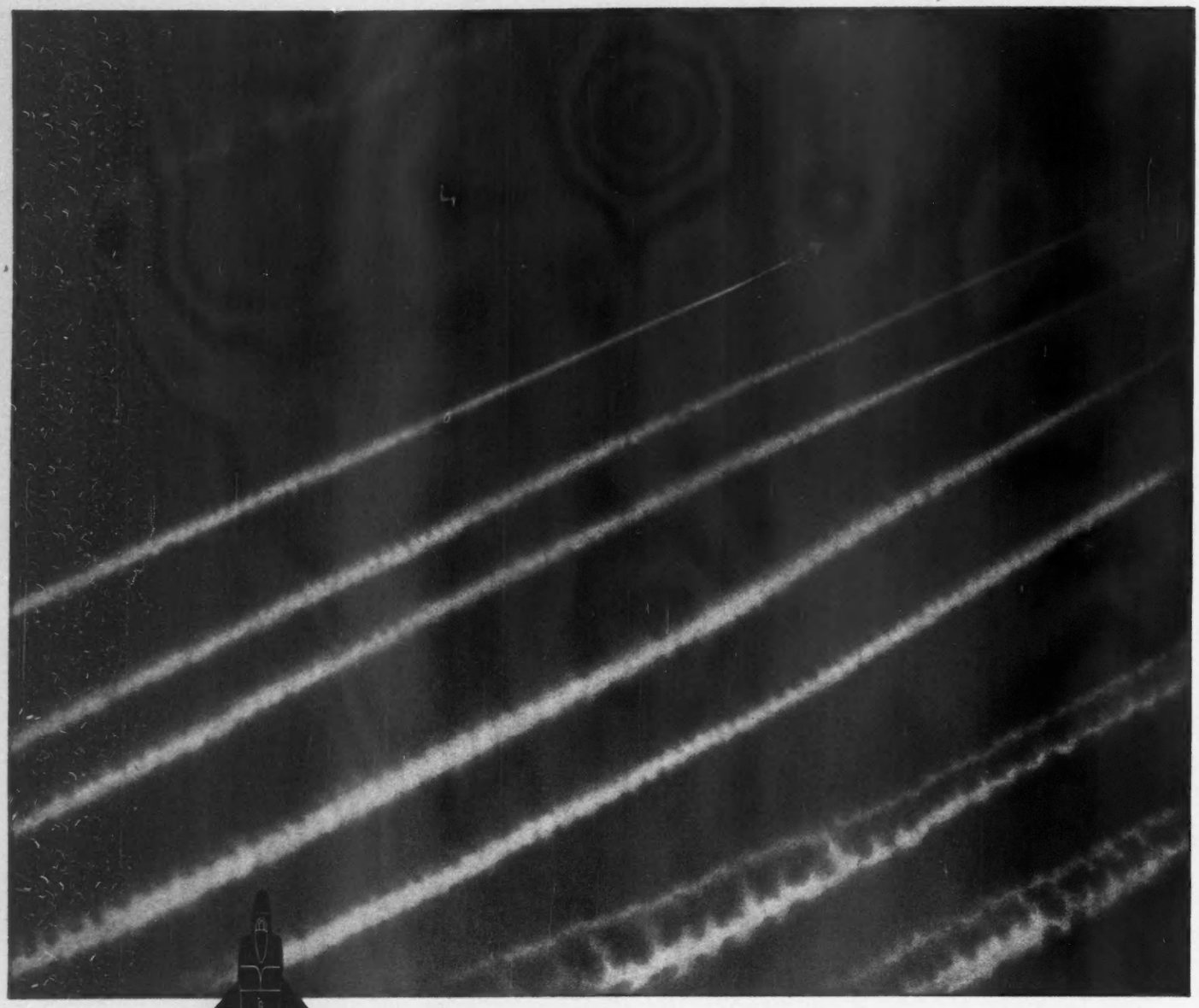

Aviation

There are few industries which, for speed of evolution and progress, can be compared with the aircraft industry. The key to this rapid growth has been research, and it is in this field that 'VSG' variable delivery hydraulic pumps and transmission gears have played an important part not only in this country but overseas.

Test rigs of various kinds both for airframe and jet engine development have incorporated 'VSG' equipment as being most suitable for giving that precise control necessary to simulate the required conditions.

This is just another of the highly varied applications of 'VSG' which has now been serving modern industry for fifty years.

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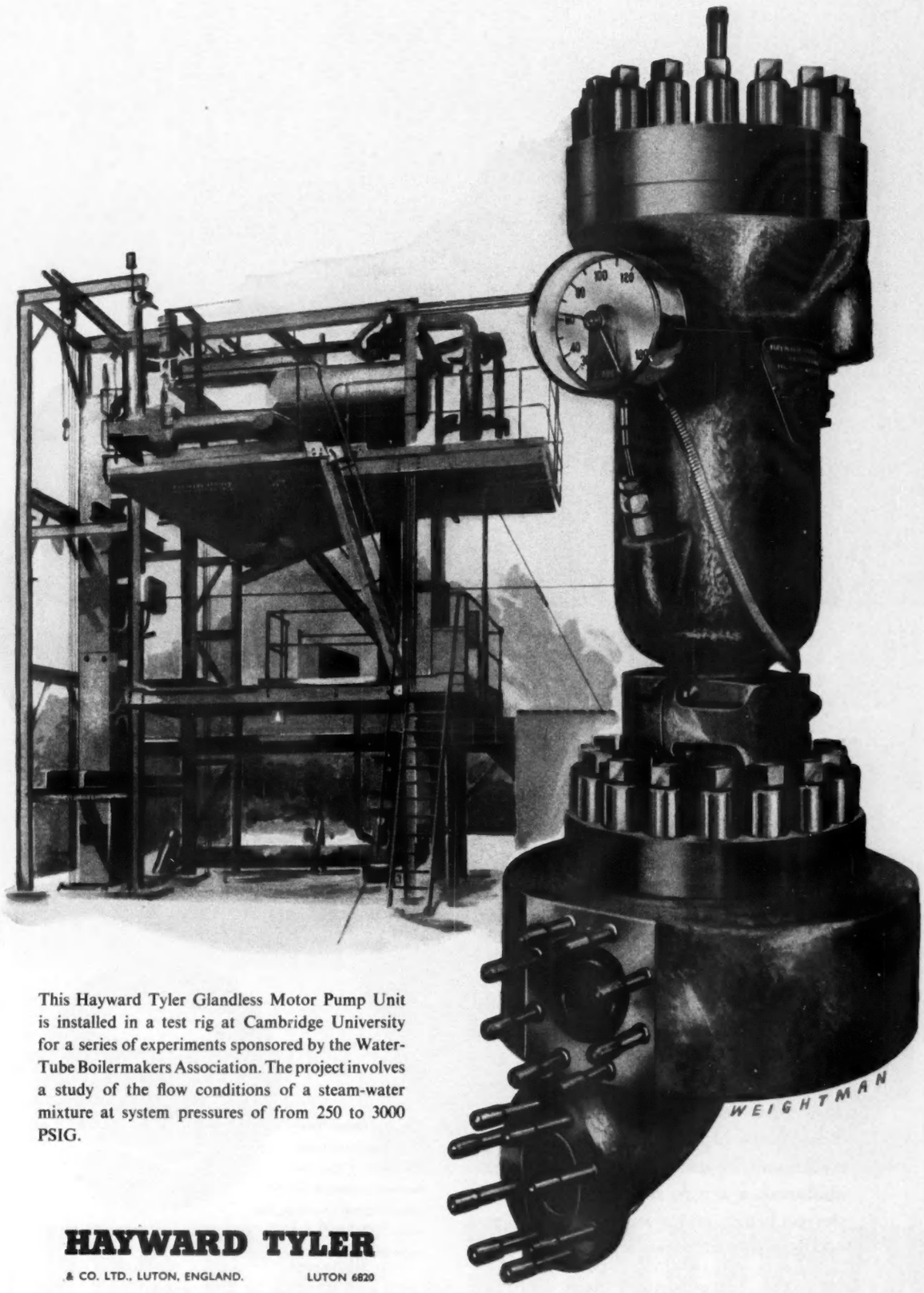

This Hayward Tyler Glandless Motor Pump Unit is installed in a test rig at Cambridge University for a series of experiments sponsored by the Water-Tube Boilermakers Association. The project involves a study of the flow conditions of a steam-water mixture at system pressures of from 250 to 3000 PSIG.

HAYWARD TYLER

& CO. LTD., LUTON, ENGLAND. LUTON 6820

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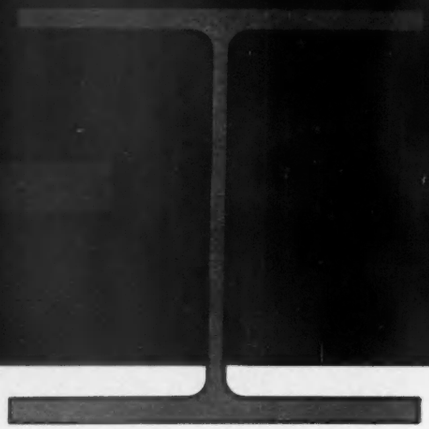

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With this mill we can now roll 'H' and 'I' sections from 6 inches deep by 6 inches wide up to 36 inches deep by 16½ inches.

Further, this versatile mill can roll all these sections in different thicknesses, so that constructional engineers will no longer need to build up their columns and girders, except for the heaviest work.

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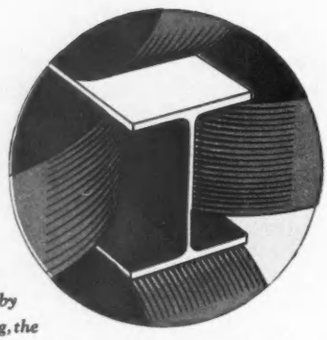
Universal beams open a new field for steelwork designers, offering far-reaching economies and increasing the efficiency of the structure.

Steelwork will become neater and of good appearance.



The variation in the flange and web thickness of the new sections is carried out by adjusting, not changing, the rolls. The small diagram shows that adjustment does not appreciably alter the surfaces shaded in red.

B.S. STANDARD BEAMS, CHANNELS AND ANGLES WILL STILL BE AVAILABLE

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CAST STEEL DIAPHRAGM PLATES for CEMENT MILLS

by

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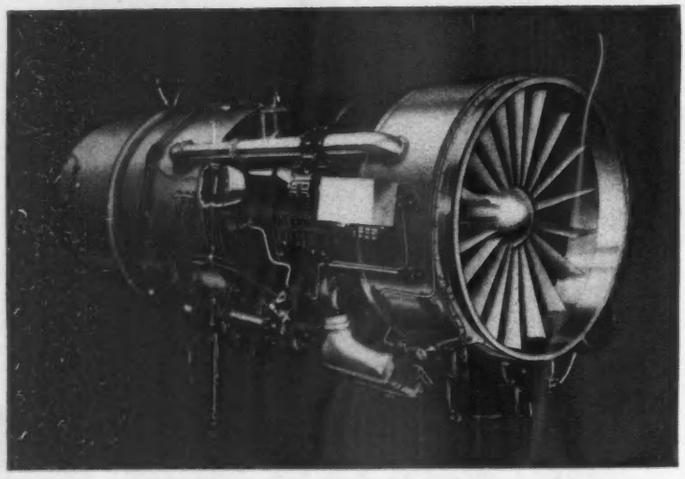
THOS FIRTH & JOHN BROWN LIMITED · SCUNTHORPE · ENGLAND



ALLOY STEELS

The Rolls-Royce Conway (left) and the Rolls Royce Dart (above, left) gas turbine aero engines make use of the unique properties of Fox Fortiweld and Jethete steels.

SAMUEL FOX & COMPANY LIMITED STOCKSBRIDGE WORKS · SHEFFIELD · ENGLAND

A subsidiary company of The United Steel Companies Limited

THE UNITED STEEL COMPANIES LTD

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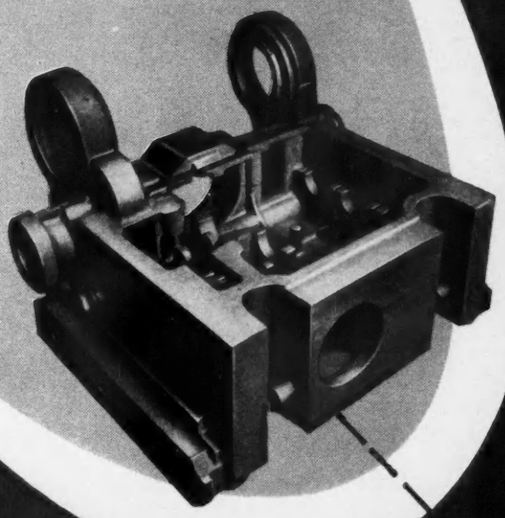

Sound and true carbon steel castings are the hallmark of A.F.C.

Our metallurgical laboratory exercises a strict control . . . Gamma Ray tests and inspection ensure soundness . . . pattern and drawing tests guarantee accuracy.

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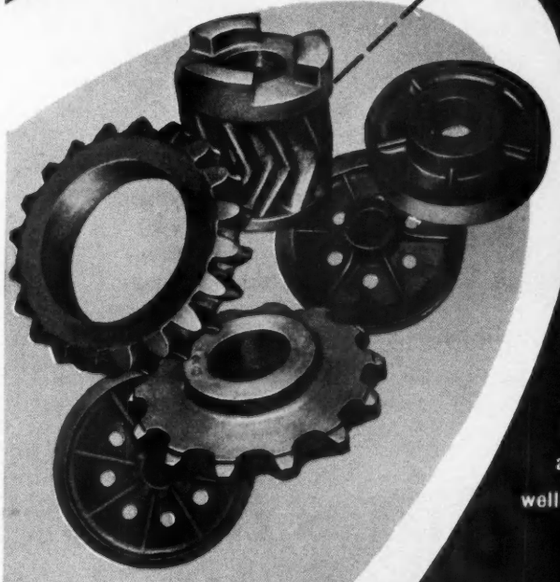
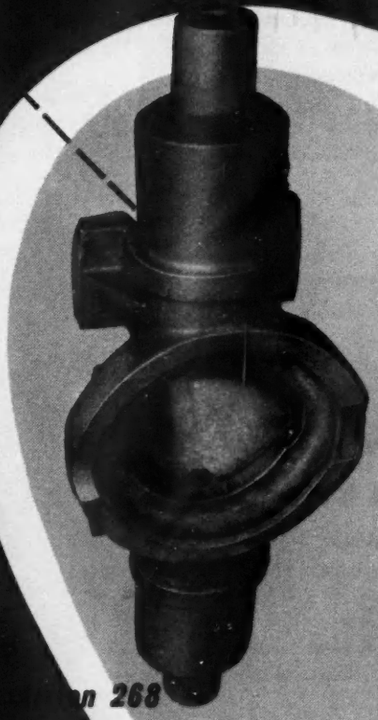
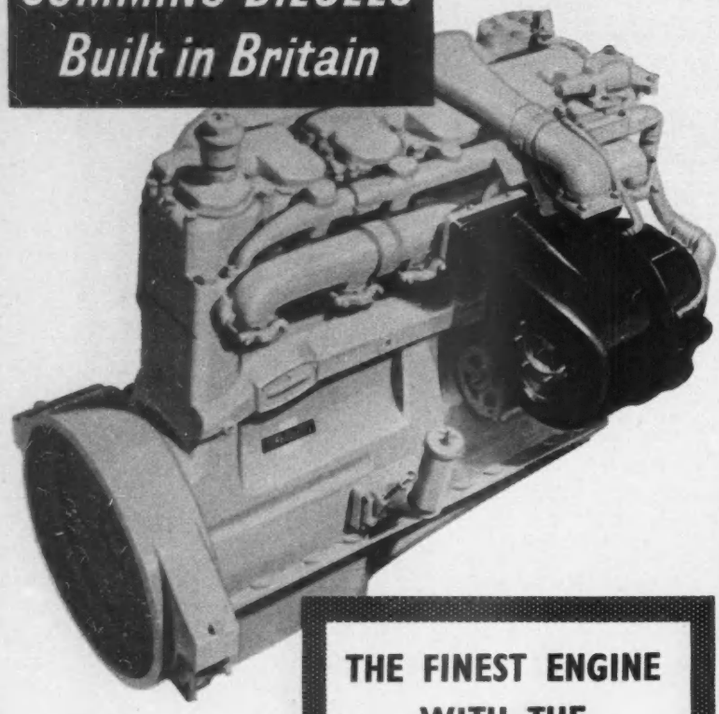


Specialists in the casting of crane and railway axle and gear boxes, buffers, guides, spur and bevel wheels also pinion blanks - in addition, of course, to our well-known coal mining machinery castings.



NENT FORCE FOUNDRY, ...n 268

CUMMINS* DIESELS
Built in Britain



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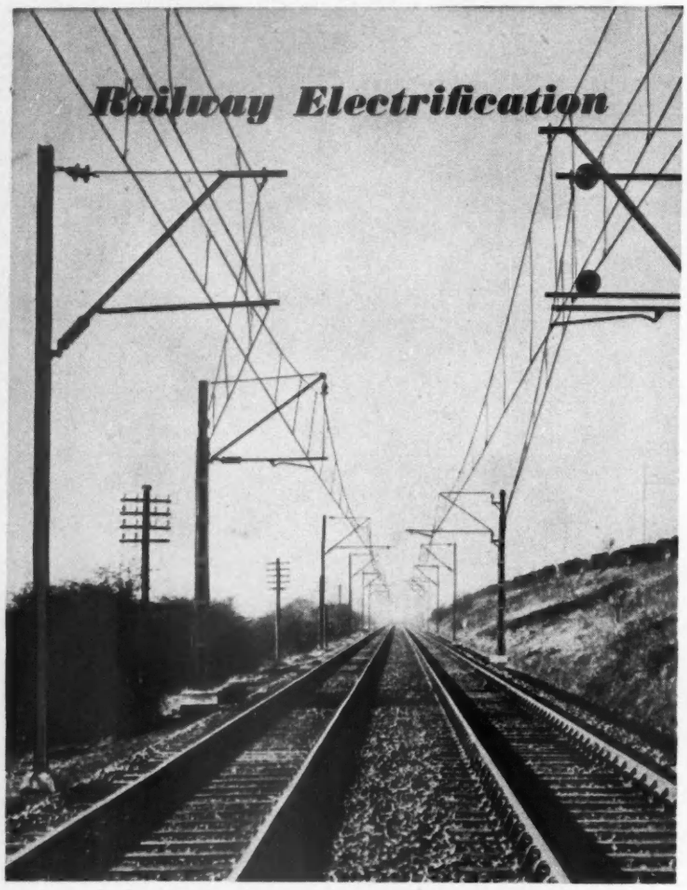
**Trade Mark of Cummins Engine Company, Inc.*



One of the latest of the many railway electrification schemes (Conductor Rail and Overhead Systems) for which Bullers have supplied insulators and fittings during the past 50 years.

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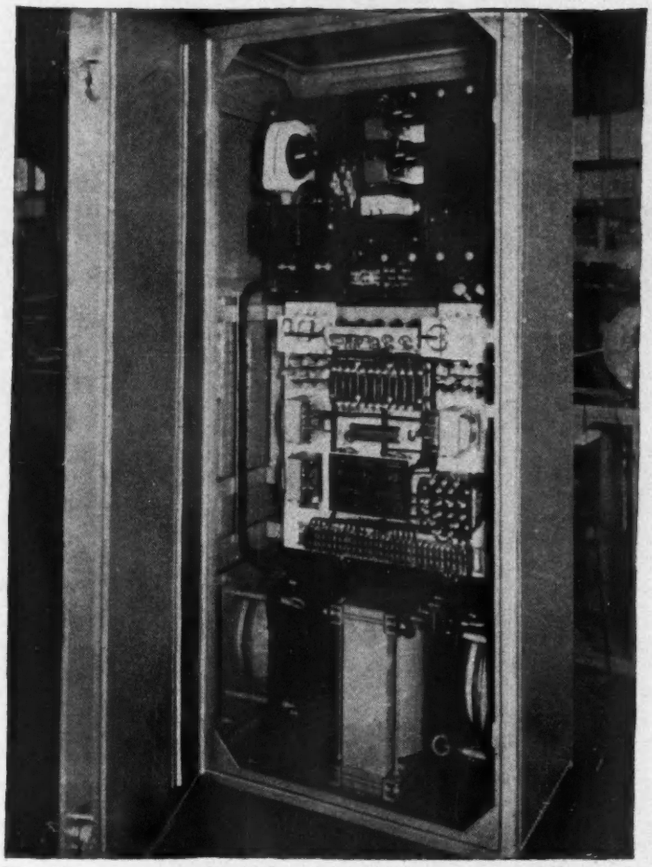


The Fluxetter control cubicle—for a 200 hp. motor speed control.

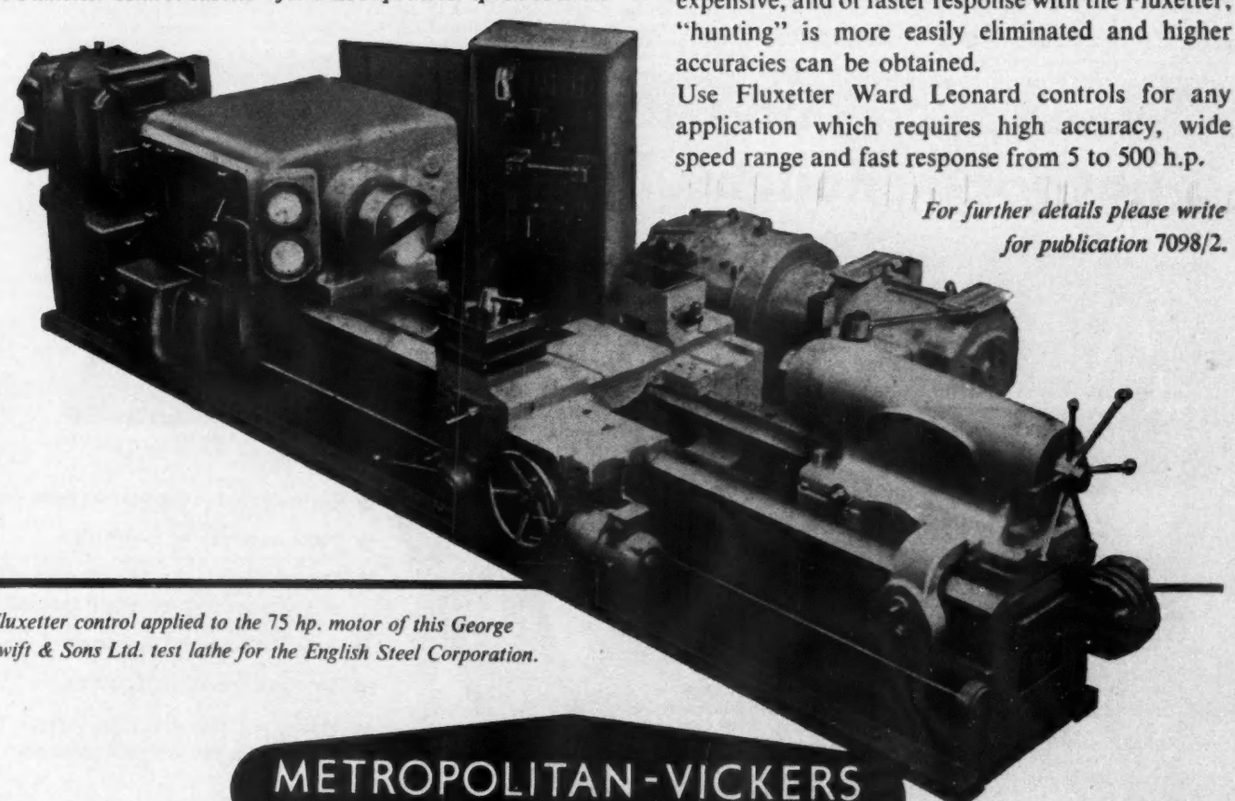
FLUXETTER

A New Magnetic Amplifier Control

"Fluxetter" is the Metropolitan-Vickers trade name for their Flux Resetting Magnetic amplifier which responds to applied signals in approximately 1/100 second on a 50 cycle supply. The principal application to date is for electronic Ward Leonard motor speed control. Such controls are simpler, less expensive, and of faster response with the Fluxetter; "hunting" is more easily eliminated and higher accuracies can be obtained.

Use Fluxetter Ward Leonard controls for any application which requires high accuracy, wide speed range and fast response from 5 to 500 h.p.

For further details please write for publication 7098/2.



Fluxetter control applied to the 75 hp. motor of this George Swift & Sons Ltd. test lathe for the English Steel Corporation.

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ELECTRICAL CO LTD · TRAFFORD PARK · MANCHESTER, 17

An A.E.I. Company.

PRACTICAL ELECTRONIC MOTOR CONTROLS

H/A502

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OSOTITE **A SLICK PRODUCT**

SLICK-BRANDS LIMITED
WADDON CROYDON

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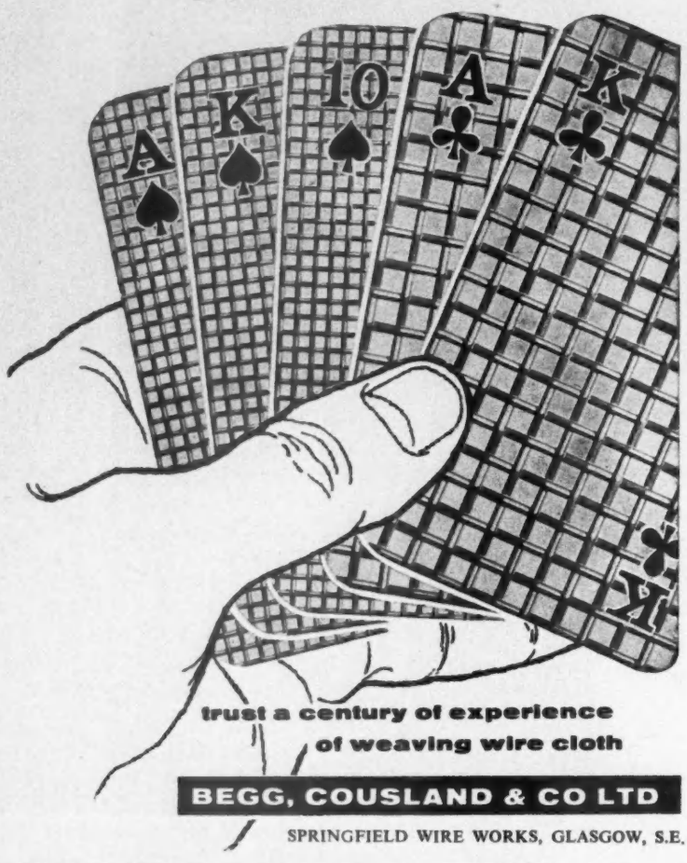

trust a century of experience of weaving wire cloth

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SPRINGFIELD WIRE WORKS, GLASGOW, S.E.

***When 'near enough' is not good enough...**

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PRECISION TORQUE SPANNERS

L3 TEST RIG

- ★ Control torque application automatically
- ★ Make overloading impossible
- ★ Do not depend on the vision, care or skill of the operator for their accuracy
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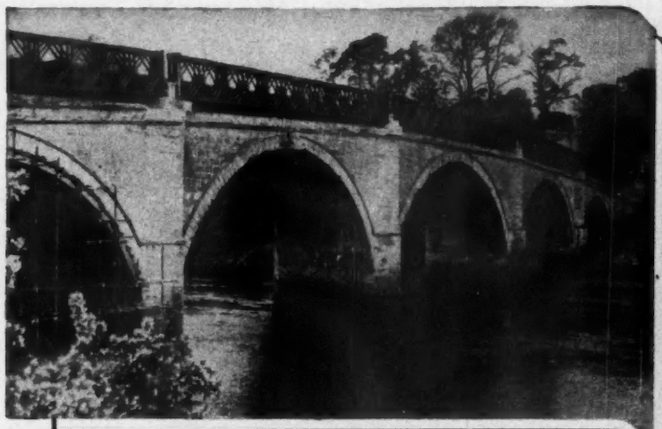

COURTESY: SCOTTISH HOME DEPARTMENT (ROADS DIVISION)

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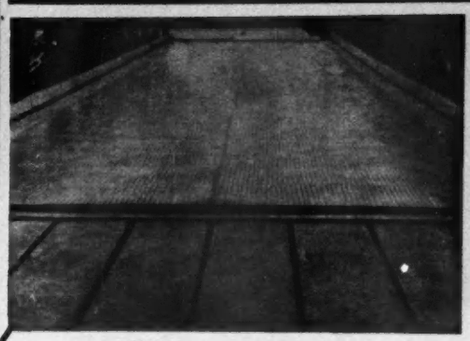

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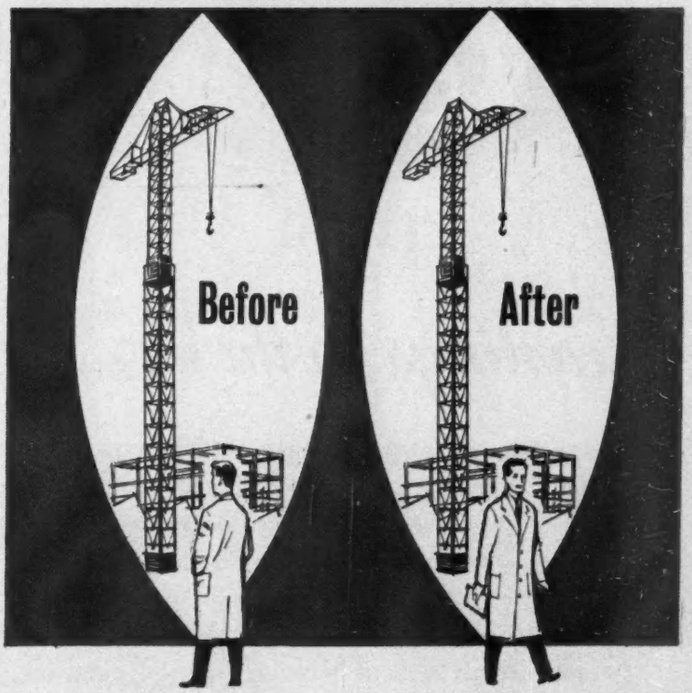

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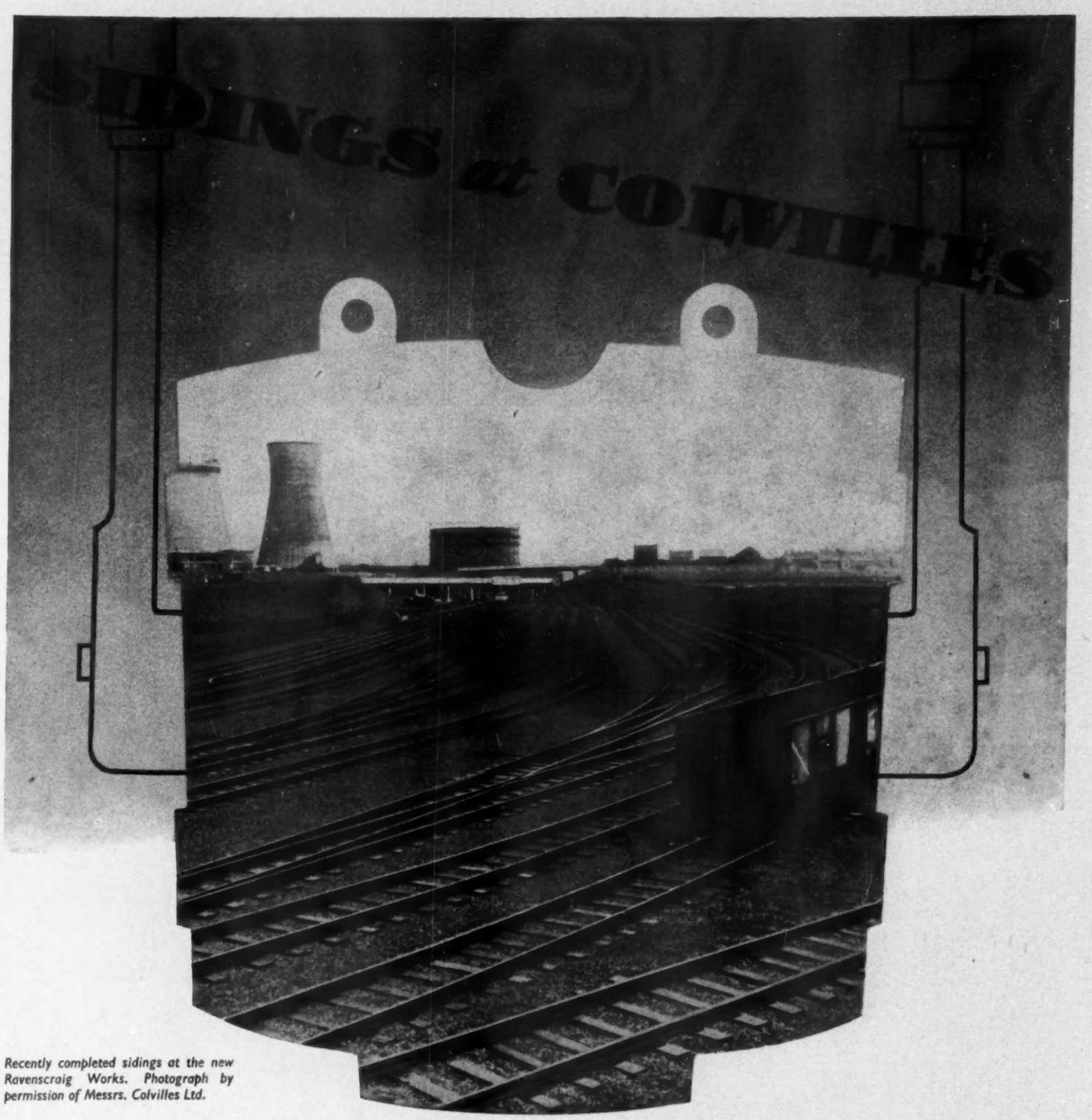

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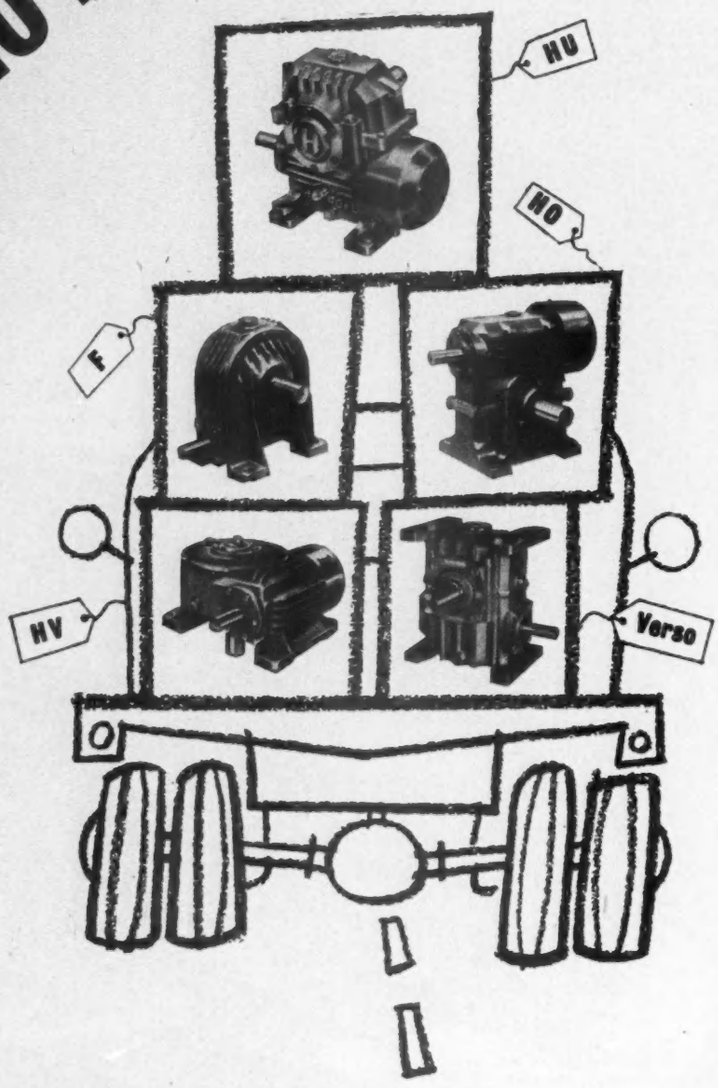

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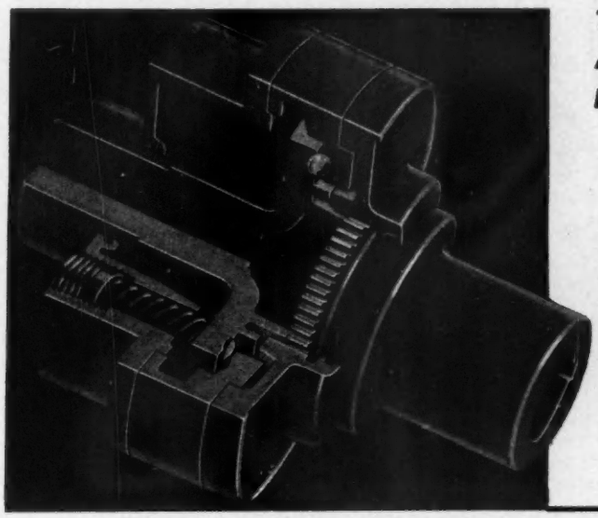

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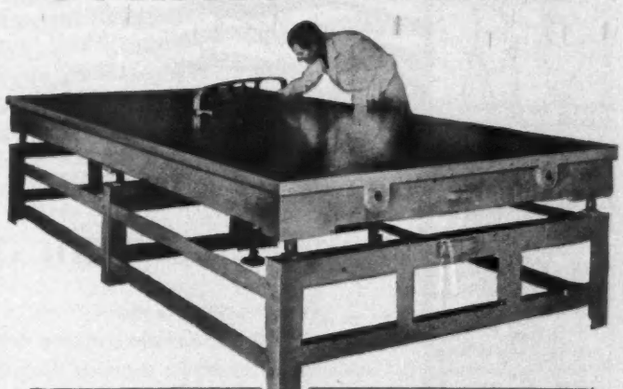

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THE ENGINEER

No. 5350 AUGUST 8, 1958 VOL. 206

POLICY OF THE ENGINEERS' GUILD

During its birth pangs shortly before the war, the Engineers' Guild came to a courageous decision which robbed it at that time of perhaps half the membership it might initially have enjoyed. It resolved that an essential qualification for membership of the Guild should be membership of one of the three major engineering institutions, the Civils, Mechanicals or Electricals. The rightness of that decision has often since been challenged by individual members but the Council of the Guild has never wavered. Nor, now that the members are to be asked this autumn whether or not to associate the Institution of Chemical Engineers with the other three is there any real sign of wavering to-day. For the members are to be asked to decide not whether to lower the qualifications for membership but whether in their estimation this fourth Institution has reached the same " major " status as the other three. But in another field and throughout its life so far, the Guild has tended to waver, has remained until recently undecided, and has, in action, proved none too consistent. It has sheered away from any suggestion that it should become a trades union; and yet inconsistently, by giving implied and sometimes more active support to collective bargaining in settling the salaries of engineers it has acted like one. Now, however, it has just reached another courageous decision. As a consequence of detailed examination of the point by the Guild's Professional Interests Sub-committee, the Council recently resolved that it should be the policy of the Guild only to influence the activities of joint negotiating committees " in so far as matters of professional concern are involved." Its main purpose will be " to seek a position where its numerical strength, knowledge of conditions and degree of influence will enable it to secure acceptance as the recognised consultant to engineers and their employers in the interests of the profession." The Council has also resolved that it shall be an aim of the Guild " to seek legislation enabling professional engineers to withdraw as a group, from collective bargaining machinery in any particular field. . . ."

The sub-committee which examined the position came to the conclusion that the merits of a system of collective bargaining are principally practical. No other system, it can be argued, can so effectively represent the economic interests of professional employees, and since power is a factor of size it is desirable to have only a few large bodies organised as trade unions to carry on negotiations. Such bodies can number therefore only minorities of professional engineers amongst their members. Typical of such bodies are the National and Local Government Officers' Association, the Institution of Professional Civil Servants, the Electrical Power Engineers Association and the Transport and Salaried Staffs Association. The sub-committee also came to the conclusion that the arguments against collective bargaining for the professional engineer are mainly ethical. The professional engineer, for example, as part of the managerial team, should not, it considers, simultaneously form part of a pressure group whose interests may conflict with those of management ; and he should not be associated with the kinds of " sanctions " which underlie trade union negotiations. By becoming a unit in a pressure group, he may gain increases in remuneration at a cost to his professional status and expose himself to the risk of belonging to an association whose policy or actions may conflict with his professional responsibilities. Experience has shown that such conflicts of interest can in real fact occur, as for example, when the T.S.S.A. instructed its members to " work to rule " in January, 1956, and the E.P.E.A. issued the same instruction to its members in February, 1957. The sub-committee argues—in our view with overwhelming force—that by behaving as an independent professional individual, the engineer " will deserve and may hope to command a greater respect from his employer." Engineering bodies in the United States and Canada are, in the committee's view, increasingly accepted by employers in a capacity akin to that of a consultant on the economic interests of the professional engineer. Those conclusions are noted by the Guild's sub-committee in a document that is a model of brevity in presenting the facts and the logical arguments that can be based on the facts. The decision of the Guild's Council to accept those conclusions and to act upon them may well bring into the Guild many professional engineers who have so far fought shy of membership for the very reason that the Guild seemed to them to act or to be capable at some future time of acting like a trade union and without sufficient respect for professional ethics. For all doubts are now resolved. The Guild knows far better than it did where it is bound.

BRITISH SATELLITES ?

The time has undeniably arrived when this country must decide either to extend its rocket research activities to include the setting up of artificial satellites or to leave astronautical experience to other nations. The temptation to decide in the affirmative is obvious and strong, but some of the arguments set forth to justify such a decision seem to us ill-considered. It has been suggested, for instance, that the prospect of the Chinese Academy of Sciences having its own earth satellite, disclosed recently by its president, Mr. Kuo Mo-Jo, portends a serious blow to the prestige of Great Britain. This is not merely far-fetched ; it is so absurd as to tickle the risible faculty. For no one will regard it as a particularly fine achievement for this country to build a bombardment missile with propulsion and guidance derived from United States practice, and launch it years after the Soviets have developed longer-ranged weapons. Yet it appears that the Chinese will lean even more heavily upon foreign rocket technology than does Britain. Furthermore it will probably prove exceedingly difficult to estimate the relative excellence of astronautical machines, since simple measures such as initial/final mass ratio or

maximum attainable velocity are influenced seriously by the position and direction of launching ranges available and the difficulty of attaining the desired course. There already exist opportunities for the direct demonstration of technical supremacy which many nations have exploited successfully, for instance, the international recognition of records for speed in specified vehicles. More satisfying, perhaps, is straight competition, as practised for sailplanes, motor-cycles, racing and sports cars. The observer devoid of national loyalties might survey such contests without being forced to the conclusion that Britain and China had no worlds left to conquer.

The avowed object of the present artificial satellites is scientific discovery, and it is when Professor Lovell, for instance, advocates this nation placing one in orbit for that purpose that the discussion becomes seriously justified ; and there is truth in the argument that unless this nation does so British scientists interested in that field will emigrate elsewhere. However, science has attained its present eminence largely by virtue of being international in participation and dissemination, and it is not easy to visualise scientists in this country being less than fully occupied in other fields, should that field be closed to them. For scientific purposes, a new vehicle would be justified only if it was going to do what had not been done before or do it more cheaply. But to surpass the performances made possible by the great research programmes that have sprung from military needs in the pioneering powers can hardly be thought to lie within the ability of any other nation. One consideration might upset this argument completely : that the technology of this country had consumed the stock, generations old, of scientific knowledge available and was now limited in its expansion by the rate of basic scientific (as opposed to technological) research. This is a situation which has been encountered in particular fields in the United States of America and no doubt elsewhere. We described, for example, only a week or two ago the way in which research on semi-conductor materials was exploited to avoid the foreseeable saturation of the Bell Telephone system. In this country, however, it is our belief that only military projects seeking the ultimate attainable at a given date have seriously encountered this limitation, as did, for instance, work upon the development of the atomic bomb. But since we now no longer aspire to be self-sufficient for weapons, we are free to concentrate on closing up, rather than extending, the gap between discovery and exploitation of natural phenomena.

The objection to the undertaking of a satellite launching programme is, in our view, not overweighed by the argument that such work is necessary to keep able engineers gainfully occupied. Negligibly often do we come across projects on which engineers have been lavished, much more frequently do we judge that an attainment would have been possible at an earlier date had more technical effort been exerted. In particular, the extremely refined and highly loaded machinery of space travel will be required to function with near-perfect reliability, and that is not achieved without development work unrestricted in its thoroughness. But if there is one natural limitation upon British technical achievements, it is the shortage of the exceptionally imaginative and enlightened engineers who can visualise the fundamental limitations of a machine design within those limitations, and foresee what lines of research will lead most directly to advances in design. There are not nearly enough to go round. Furthermore, is the capital available to provide the elaborate and expensive facilities with which they must be equipped for astronautical researches ? Our readers will know whether they are or are not called upon to extend themselves fully in their employment, but we, noting that a completely fresh design even of a motor-cycle is unusual in this country, are convinced that our progress is limited to a significant extent by the scarcity of engineers. Certainly this is a more welcome explanation than any other when we are confronted with the relatively advanced status overseas of automatic machine tools, variable geometry propellers, supersonic aircraft, two-stroke piston engines, fuel injection systems, and vehicle suspensions, and is, of course, the justification for our especial dependence in nuclear power on the gas-cooled graphite-moderated reactor.

There is only one argument that appeals to us as possibly adequate justification for research by this country in the astronautical field. It is that when engineers enter a new field of endeavour, especially one making extreme demands upon the materials used and the ingenuity of designers, contractors and research workers, scientific and technological discoveries are made which subsequently influence the whole thinking of engineers in general. In this country we have seen how the development of aircraft (and of motor vehicles) has had just such an influence over the whole field of engineering. If we are to aspire to be leaders in the world in engineering design and development dare we neglect to enter also into the development of astronautics ?

AS-YOU-WERE ABOUT CANALS

The Committee of Inquiry into Inland Waterways which issued its report last week came to agreed conclusions upon all points except two of the more important. But unfortunately it was hopelessly divided in its views about the future ownership and management of nationalised waterways and about the means for dealing with the redevelopment of waterways of all types. We think it must be conceded that the major object for which the Committee was set up was to still controversy about the future of waterways. But that controversy centred around those very points upon which the Committee could not reach agreement ! No one can really expect, therefore, that the report will suffer any fate other than to be put on a shelf and forgotten. Yet it will be a pity if it is not widely read before it suffers that fate. For it sets out the present position with great clarity and, until major decisions are taken to do something different, no great change in present circumstances is likely to occur. Moreover some of the minor agreed conclusions are sensible and merit remembrance and might beneficially be applied at once. Broadly Britain's inland waterways can be separated into three groups, those which can be operated profitably and upon which it is worth while spending capital upon improvement ; those which are still in use for transport but remain nevertheless a liability to the present owners, the British Transport Commission, since they run at a loss ; and those which are seldom or never used for transport and are never likely to be economic for that purpose, which are in varying states of dilapidation already and which need re-development for other purposes. The significant recommendations of the Committee which deserve not to be forgotten relate especially to the latter two categories. They are that, to whosoever's hands the canals are eventually entrusted, the financial loss on the second

group of canals should be met by a governmental subsidy partly on the ground that the waterways serve other useful purposes besides that of transport, as for example in supplying water to industrial users, carrying away some industrial effluents, and providing amenities. As for the third group, whoever owns the canals should endeavour to dispose of them, having first put them into such degree of repair, as waterways, as will suit their new purpose. It was upon ownership and operation that the Committee split. One side proposes that ownership should be left with the British Transport Commission and that a Waterways Re-development Board be appointed for the purpose of preparing schemes for the re-development or elimination of uneconomic waterways. The other side suggests that ownership by the Commission is inappropriate. It proposes that a separate Inland Waterways Corporation should be set up to take charge of them. That body should also be responsible for re-development. Our own impression is that the British Transport Commission would part with its responsibility for canals with few regrets. A loss is made upon their operation and they play a very small part in the whole of the nation's transport.

THE SUBMARINE SITUATION TO-DAY

Britain's request, recently approved by the United States Government, to purchase from an American firm a complete nuclear submarine propulsion unit is a clear indication of the importance the Admiralty now attaches to building a flotilla of nuclear-powered submarines as soon as financial resources permit. The principles of nuclear power are in many ways simple ; but the problem of producing a power plant for the propulsion of ships, which is compact, light in weight and not too costly, requires a great deal of investigation and research. While Britain concentrated on developing nuclear plants for the generation of electricity, the United States started ten years ago to investigate the most suitable type of plant for warships. After trying out sodium and other coolants, she finally decided on a reactor moderated and cooled by pressurised-water and fuelled with enriched uranium. At the present time there are six variations of this kind of reactor, either built or under construction. The recent agreement will certainly result in the commissioning of Britain's " Dreadnought " much sooner than was anticipated. The time has indeed now arrived when the British people must reorientate their ideas about the submarine. Nuclear power has brought about a complete revolution in naval warfare. It has changed the submarine from a relatively cumbersome and slow-moving craft—which nonetheless twice nearly brought this country to her knees in the two world wars—into a submerged vessel which is as fast and as manœuvrable as a surface ship. Proceeding submerged for as long as desired at speeds of 25 knots or more, and at varying depths between 500ft and 1000ft, she is going to be extremely difficult to locate and destroy.

The United States has already nineteen of these nuclear powered submarines, built, building or authorised. They include one equipped with the 1000-mile " Regulus " guided flying bomb ; seven " high-speed attack " submarines of the 2700-ton " Skipjack " class, with a hull shaped like a whale ; and four very large (5600-ton) submarines to be armed with sixteen 1500-mile " Polaris " ballistic rockets for launching while submerged. Most of the remainder are overseas patrol submarines of the " Skate " type, a 2190-ton version of the much larger and more costly 3200-ton prototype " Nautilus." Britain urgently requires submarines still smaller than the " Skate," equipped with a smaller reactor but with a hull similar to the " Skipjack " class, which in conjunction with nuclear power, will give them a submerged speed of between 30 and 40 knots. It is a submarine of this size and type which will provide one of the most effective means of locating and destroying the large ballistic launching submarine. Naval experts and other enthusiasts, who realise the great increase of offensive and defensive capability given to the submarine by nuclear power, urge that Britain should also build rocket-launching submarines. There could certainly be no safer nor more effective deterrent. But the estimated cost of these large United States submarines is between £30,000,000 and £35,000,000, as compared with £16,000,000 for the " Skate." And though these costs might well be reduced by at least a third if the vessels were British built, Britain for many years yet will not be able to afford over £20,000,000 for a submarine whose sole purpose is to fire a ballistic rocket.

What of the submarines of the Soviet Navy ? There are indications that Russia has slowed down on submarine construction. But this it may be assumed is *pour mieux sauter*. Russia does not hesitate to inform the world that she is quite prepared, if necessary, for nuclear war. She has also let it be known that she has an intercontinental rocket, though there is no evidence that its range is anything like 5000 miles. But she is in the forefront in her nuclear capability and no nation is better able to guard military secrets which are of real importance. We would be wise to assume that she too has realised the greatly increased value given to the submarine by nuclear power and is not far behind the United States in the construction of large ballistic-rocket-firing submarines.

The Engineer— 100 Years Ago (AUGUST 6, 1858)

" SCIENCE SCHOOLS."

" From the fifth annual report of the Science and Art Department, it appears that there are in the United Kingdom nineteen schools of this class including twelve purely navigational schools, the whole attended by an aggregate of 3120 students, being a reduction of 443 students as compared with the previous year. The navigation schools are by far the most popular, and in Liverpool there are 753 students, which is a falling-off, however, of 488 as compared with the foregoing year's attendance .... The only science school of which a separate report is given is one at Leeds, where there are 113 students, showing a decline of seventy-four on the year. There are two mining schools existing, one at Truro with fourteen students, and one recently established at Wigan.

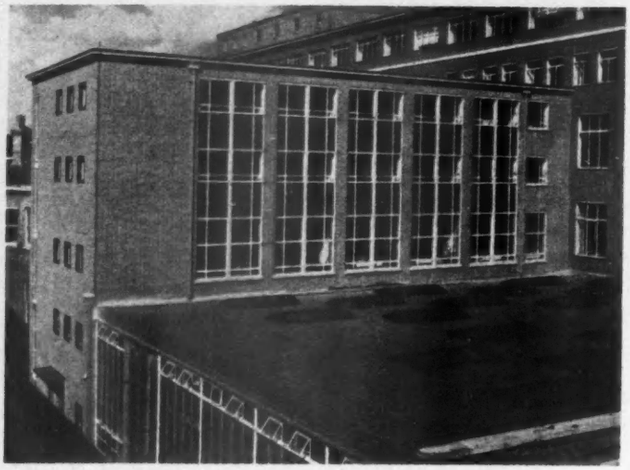
" As another progressive step pupil teachers have been appointed for science teaching. Masters in training have also been sent to assist in the instruction of Junior pupils in country schools ; whilst assistant masters for science have been appointed with a salary of £80 a year, half paid locally and half by the Department, on condition that they pass in groups one or two of the navigation certificates at the end of the first and second years respectively .... We believe the class of teachers suited to this work has as much to be created as art teachers have. Had we said more so, it would not have been difficult to justify the assertion, as is proved by the fact that every town had its drawing master before the Department for art existed, whilst comparatively few have now a science teacher of equal standing .... The teaching of science in popular schools is generally a sham or a failure, as far as our observation has gone, and it has been so because it has not been made a specialty of, and has not been committed to the hands of a qualified teacher, whose sole business it is to teach it."

Plastic Design of a Four-Storey Steel Frame

By M. R. HORNE, Sc.D., A.M.I.C.E.

No. I

The design of the four-storey steel frame at the new extension of Cambridge University's engineering laboratory is explained in detail in this article. The completed building, illustrated on the right, is the first multi-storey office or laboratory structure to have been designed by plastic theory. After following through the main design calculations, joint detailing and erection are described, and the plastic design is compared with other design methods.



A GENERAL description has already been given[1] of the recently opened extension to the engineering laboratory at Cambridge. The extension consists of the central wing and adjacent single-storey laboratories in what will ultimately be an E-shaped building above ground floor level, as shown in the site plan in Fig. 1. The spine

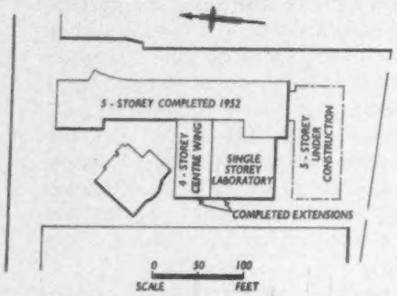


Fig. 1—Site plan

of the building, opened in 1952, is five storeys high, while the central wing has four storeys. A South wing, five storeys in height, is now under construction. A photograph of the completed steelwork for the central wing and single-storey laboratory is shown in Fig. 2.

The steel frame, of which a plan and elevation are shown in Fig. 3, is a welded rigid frame designed by the plastic theory. The engineers were Messrs. R. T. James and Partners in collaboration with Professor J. F. Baker and the author, while the contractor for the steel frame was Harland and Wolff, Ltd. The architects were Messrs. Easton and Robertson, and the main contractor Sindall (Cambridge), Ltd.

The whole of the ground floor of the new extension, apart from the entrance and stair well shown shaded in Fig. 3, consists of a laboratory of height 20ft. The single-storey bay adjacent to the central wing carries a hand-operated crane of 2-ton capacity, the rails being slung from the roof beams. The first floor of the centre wing also consists of a laboratory, while the two uppermost floors each consist of two rows of study rooms either side of a central corridor. The main frames are at 11ft centres, this being the standard module for the building. The main spans of 33ft were chosen as most suitable for the ground and first floor laboratories. A restriction on the total height of the building, imposed by day lighting and building density regulations for the site, limited the two uppermost storey heights to 9ft between beam centres, and beam spans of 33ft could not have been retained had it not been for the reduction in beam depths made possible by the adoption of rigid welded construction.

The cladding of the building consists of brick exterior walls, with steel decking spanning 11ft between frame centres on the single-storey roof. The floors are *in situ* reinforced concrete, as also is the roof of the centre wing.

The distributed roof and floor loads (working values) and total factored loads per beam (load factor 1·75) are shown in Table I.

TABLE I—*Roof and Floor Loads*

		Centre wing			Single-storey laboratory roof
		Floor 1	Floors 2 and 3	Roof	
Distributed loads, lb/sq. ft (Unit load factor)	Dead	120	135	100	13
	Live	150	50	30	30
	Total	270	185	130	43
Total loads per beam, tons (Load factor 1·75)	Dead	33·9	38·2	28·3	3·7
	Live	42·3	14·1	8·5	8·5
	Total	76·2	52·3	36·8	12·2
$g = \frac{\text{Dead load}}{\text{Total load}}$		0·44	0·73	0·77	0·30

The last row in the table gives g, the ratio of dead to total load on the beams and roof members. As described later, this quantity is of importance in the design method used.

General Basis of Design

The main frames were designed with welded rigid joints to a load factor of 1·75 for dead plus superimposed loads. The wind loading condition was not critical, since all sway forces could be assumed to be taken by the end wall on the west face and by the existing building at the east end of the wing. The whole of the frame was therefore designed for vertical loading only, the assumption being made that the stanchions were restrained against sway deflection at each floor level.

In the application of plastic design methods to multi-storey buildings in which sway is present, the main complication as compared with the design of single-storey buildings lies in the allowances that have to be made for heavier axial loads. The various possible approaches to this problem have been summarised elsewhere.[2, 3] At present, the most practicable method is that in which the beams are designed in the most economical manner possible, their collapse condition being the development of full plasticity at both ends and at the centre. The stanchions are then designed by predominantly elastic methods so that they are capable of taking the heavy moments imposed by the beams. A suitable method of stanchion design has been developed,[2, 3] and this procedure has been used for the present four-storey wing. Since the method of stanchion design is

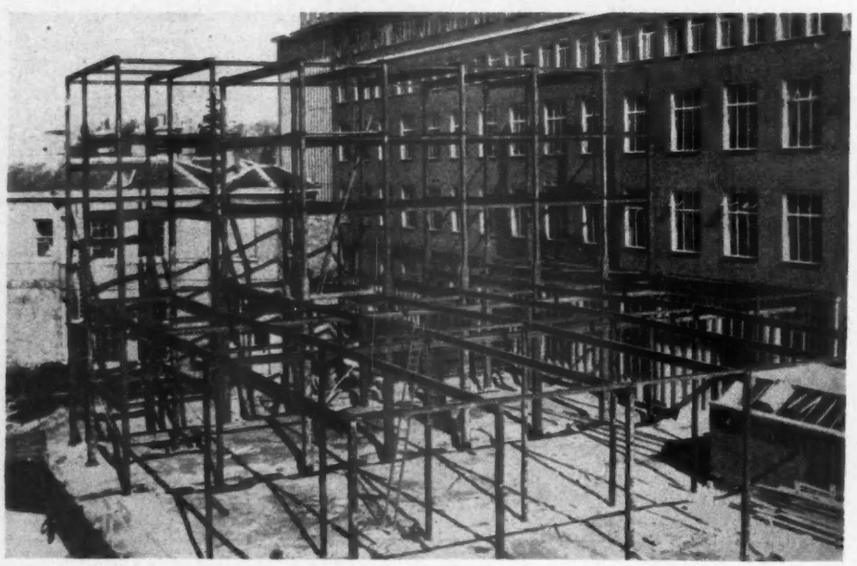


Fig. 2—Steelwork for the extensions

fundamental to an understanding of the design calculations, it will be summarised briefly. For a full treatment the reader is referred to the original paper.[2]

Design Curves for Stanchions

Suppose the I-section stanchion AB in Fig. 4 (*a*) is of length l and is under an axial load P together with terminal moments M_x^1 and M_x^{11} acting about the major axes XX and X_1X_1 respectively. The ratio M_x^{11}/M_x^1 will be denoted by β. There will also be horizontal forces R in the plane of the web at A and B to keep the stanchion in equilibrium. It is assumed that the ends of the stanchion are restrained against horizontal deflection in any direction, that the end sections are free to rotate about the minor axes YY and Y_1Y_1, and that twisting of the ends about the longitudinal axis ZZ is prevented. The stanchion is assumed to have an initial imperfection consisting of a curvature of the longitudinal axis in a plane perpendicular to the web.

The bending moments about the major axis throughout the stanchion length are shown in Fig. 4 (*b*), while Fig. 4 (*c*) shows the bending moments about the minor axis. In order that the stanchion shall just remain elastic the extreme fibre stress must not exceed the yield value anywhere in the stanchion. It has been shown that if M_x^1 is numerically greater than M_x^{11}, and the yield stress is 15·25 tons per square inch, this condition will be ensured provided

$$p+f_x^1 \leqslant 15{\cdot}25 \quad . \quad . \quad . \quad . \quad (1)$$

$$p+N_x f_x \leqslant f \quad . \quad . \quad . \quad . \quad (2)$$

where the symbols have the following meanings.

$p=\frac{P}{A}$ = mean axial stress due to load P tons, area of stanchion being A square inch.

$f_x^1=\frac{M_x^1}{Z_x}$ = extreme fibre stress due to bending moment M_x^1 tons-in, elastic modulus of stanchion being Z_x in^3.

$f_x=\frac{M_x}{Z_x}$ where $M_x=\mu M_x^1$ and μ depends on β according to Table II.

N_x This is a factor obtained from the chart in Fig. 5 (*b*) and depends on p and $\frac{l}{r_x}$, the slenderness about the major axis XX.

f This is obtained from the chart in Fig. 5 (*a*), and depends on p^1 and $\frac{l}{r_y}$, the slenderness about the minor axis YY.

$p^1=p+\frac{f_x^2}{T}$ where the quantity T is a property of the stanchion section used, and allows for the tendency of the stanchion to fail by twisting and bending about its minor axis. Values of the factor T have been tabulated for standard sections.[2, 3]

The graphs in Fig. 5 and Table II are intended merely to show the general nature of the functions f, N_x and μ. More detailed data are available in the original paper.[2] The inequality (1) ensures that the yield stress shall not be exceeded at end A, while inequality (2) ensures that it shall not be exceeded within the length of the member. It may be noted from Table II that the ratio $\beta=M_x^{11}/M_x^1$ is assumed to lie between $+1$ and -1. When the moment at B in Fig. 4 (*a*) is numerically greater than that at A, then the moment at A is called M_x^{11} and that at B, M_x^1.

Table II—*Values of* $\mu=M_x/M_x^1$

Ratio of end moments β	$\mu=M_x/M_x^1$
1·0	1·000
0·8	0·902
0·6	0·807
0·4	0·714
0·2	0·637
0	0·565
−0·2	0·502
−0·4	0·451
−0·6	0·410
−0·8	0·384
−1·0	0·391

The above design method for stanchions does not permit the development of a plastic hinge in the stanchion itself. It is possible to allow a plastic hinge at one end only, or at both ends ($\beta=-1$), provided the mean axial stress is sufficiently low. This problem has been fully investigated and design curves have been produced.[3] These curves are particularly useful in the design of stanchion lengths near the top of a building where axial stresses are low.

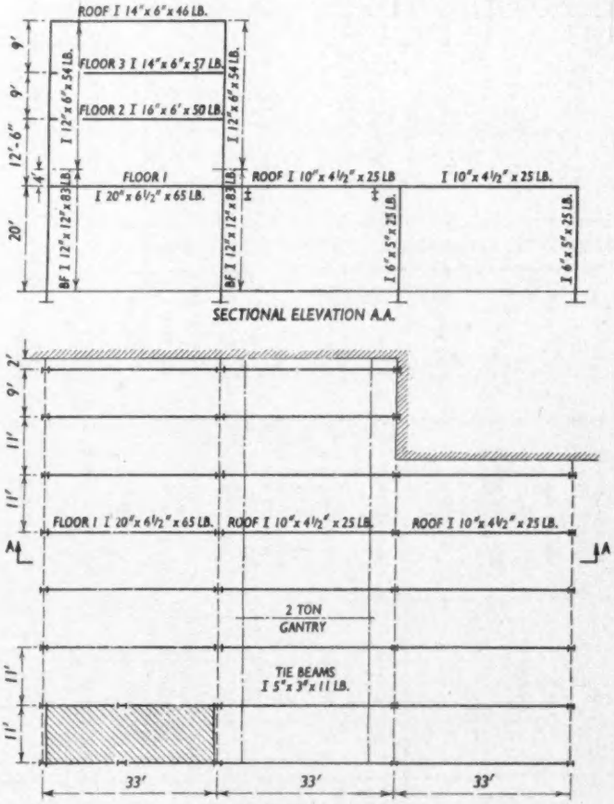
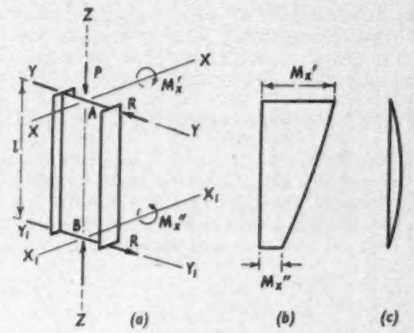

ROOF I 14"x 6"x 46 LB.
FLOOR 3 I 14"x 6"x 57 LB.
FLOOR 2 I 16"x 6"x 50 LB.
FLOOR I
I 20"x 6½"x 65 LB.
ROOF I 10"x 4½"x 25 LB
I 10"x 4½"x 25 LB.
SECTIONAL ELEVATION A.A.
FLOOR I I 20"x 6½"x 65 LB.
ROOF I 10"x 4½"x 25 LB.
2 TON GANTRY
TIE BEAMS I 5"x 3"x 11 LB.
33'
PLAN FIRST FLOOR AND ROOF.

Fig. 3—Outline drawing of steel frame



(*a*) Loaded I—section stanchion.

(*b*) Bending moments about major axis.

(*c*) Bending moments about minor axis.

Fig. 4—Loads and bending moments on stanchion

Estimation of Stanchion End Moments

Suppose Fig. 6 represents two bays of a multi-storey frame. Let W_1, W_2, &c., be the total factored loads (assumed to be uniformly distributed) on the beams, g_1W_1, g_2W_2, &c., the total dead loads (also factored), while M_{P1}, M_{P2}, &c., are the minimum required full plastic moments. Then $M_{P1}=\frac{W_1l_1}{16}$, $M_{P2}=\frac{W_2l_2}{16}$ &c. The stiffnesses of the beams and stanchions (moments of inertia divided by length) are as indicated (K_1, K_2, K_{AD}, &c.).

In estimating the maximum clockwise stanchion moments at the joint E, it is necessary to assume that the span DE carries the dead load g_1W_1 only, while span EF carries its total load W_2. If this is the loading and beam EF has been designed economically, a plastic hinge will form at E in beam EF, but beam DE may, to a first approximation, be assumed to remain elastic. Had the joint E been clamped against rotation before the application of the loads g_1W_1 and W_2, then there would have been, after the application of the loads, a terminal moment at E in beam DE of magnitude $\frac{g_1W_1l_1}{12}$. At the same time, the terminal moment at E in beam EF would be the plastic hinge value $M_{P2}=\frac{W_2l_2}{16}$. The

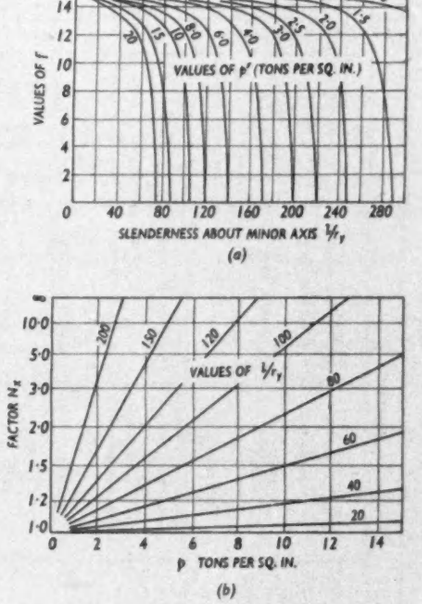


Fig. 5—Stanchion design charts

	BEAMS		STANCHIONS								
	1	2	3		4	5	6	7	8	9	10
	Load: Live = W_L Total = W_T Dead/Total = g Span (ft) = l	M_p required (tons-in) S required (in³) Section used I (in⁴)	K_1 K_2 $Q_1=\frac{K_1}{K_U+K_L}$ $Q_2=\frac{K_2}{K_U+K_L}$		Load P tons Height h (ft) Height h (in) Section used	Area A (in²) T Mean axial stress p tons/in²	$L_e/h=K$ Z_e h/r_e h/r_v	Calculation of terminal moments	β f_a^1 (tons/in²) $p+f_a^1$ (tons/in²) f_a (tons/in²)	N_a $p^1=p+\frac{f_a^1}{7}$ $p+N_af_a$	Miscellaneous
ROOF	$W_L=8\cdot5$ tons $W_T=36\cdot8$ tons $g=0\cdot77$ $l=33$ft	$M_p=910$ tons-in $S=\frac{910}{15\cdot25}=59\cdot7$in³ 14in × 6in × 46 lb I ($S=72\cdot53$) I = 442·6in⁴	$K_1=0$ $K_2=\frac{442\cdot6}{33}=13\cdot4$ $Q_1=0$ $Q_2=\frac{13\cdot4}{41\cdot8}=0\cdot32$								
FLOOR 3	$W_L=14\cdot1$ tons $W_T=52\cdot3$ tons $g=0\cdot73$ $l=33$ft	$M_p=1295$ tons-in $S=84\cdot7$in³ 14in × 6in × 57 lb I ($S=88\cdot43$) I = 533·3in⁴	$K_1=0$ $K_2=\frac{533\cdot3}{33}=16\cdot2$ $Q_1=0$ $Q_2=\frac{16\cdot2}{2\times41\cdot8}=0\cdot19$	FLOOR 3	$P=\frac{36\cdot8}{2}+3\cdot5=21\cdot9$ tons $h=9$ft $h=108$in 12in × 6in × 54 lb I	$A=15\cdot89$in² $T=85\cdot8$ $p=1\cdot38$ tons/in²	$K=\frac{375\cdot8}{9}=41\cdot8$ $Z_e=62\cdot63$in³ $h/r_e=\frac{108}{4\cdot86}=22\cdot2$ $h/r_v=\frac{108}{1\cdot33}=81$	TOP stanchion fully plastic $n=\frac{p}{15\cdot25}=0\cdot09$ $S_p=72\cdot72-126\cdot2(0\cdot09)^2=71\cdot70$in³ $M_p=15\cdot25S_p=1090$ tons-in BOTTOM dead load only $\frac{4}{3}gM_p\frac{1}{1+\frac{1}{2}Q}=\frac{1260}{1\cdot10}=1150$ tons-in $1150\frac{K_U}{K_U+K_L}=1150\frac{41\cdot8}{2\times41\cdot8}$ $=575$ tons-in	$\beta=-\frac{575}{1090}=-0\cdot53$		Stanchion fully plastic at top Chart for $T=60$ (*Steel Skeleton*, Vol. II, page 343) gives safe $p=7\cdot0$ tons/in² hence satisfactory.
FLOOR 2	DITTO	$M_p=1295$ tons-in $S=84\cdot7$in³ 16in × 6in × 50 lb I ($S=88\cdot79$) I = 618·1in⁴	$K_1=0$ $K_2=\frac{618\cdot1}{33}=18\cdot7$ $Q_1=0$ $Q_2=\frac{18\cdot7}{41\cdot8+30\cdot1}=0\cdot26$	FLOOR 2	$P=21\cdot9+\frac{52\cdot3}{2}+3\cdot5$ $=51\cdot5$ tons $h=9$ft $h=108$in 12in × 6in × 54 lb I	$A=15\cdot89$in² $T=85\cdot8$ $p=3\cdot24$ tons/in²	DITTO				
FLOOR 1	$W_L=42\cdot3$ tons $W_T=76\cdot2$ tons $g=0\cdot44$ $l=33$ft	$M_p=1885$ tons-in $S=124$in³ 20in × 6½in × 65 lb I ($S=141\cdot8$) I = 1226in⁴	$K_1=0$ $K_2=\frac{1226}{33}=37\cdot2$ $Q_1=0$ $Q_2=\frac{37\cdot2}{30\cdot1+32\cdot8}=0\cdot59$	FLOOR 1	$P=51\cdot5+\frac{52\cdot3}{2}+3\cdot5$ $-\frac{1}{10}\{\frac{14\cdot1+14\cdot1}{2}\}$ $=81\cdot1-1\cdot4=79\cdot7$ tons $h=12\cdot5$ft $h=150$in 12in × 6in × 54 lb I	$A=15\cdot89$in² $T=85\cdot8$ $p=5\cdot03$ tons/in² {in B.F. section $p=3\cdot27$ tons/in²}	$K=\frac{375\cdot8}{12\cdot5}=30\cdot1$ $Z_e=62\cdot63$in³ $h/r_e=\frac{150}{4\cdot86}=30\cdot9$ $h/r_v=\frac{150}{1\cdot33}=113$	Double curvature larger moment at bottom TOP $\frac{4}{3}gM_p\frac{1}{1+\frac{1}{2}Q}=\frac{1260}{1\cdot13}=1117$ tons-in $1117\frac{K_L}{K_U+K_L}=1117\frac{30\cdot1}{41\cdot8+30\cdot1}$ $=467$ tons-in BOTTOM $M_p\frac{K_U}{K_U+K_L}=1885\frac{30\cdot1}{30\cdot1+32\cdot8}$ $=917$ tons-in	$\beta=-\frac{467}{917}=-0\cdot51$ $f_a^1=\frac{917}{62\cdot63}=14\cdot70$ {$\frac{917}{109\cdot2}=8\cdot40$ in B.F. section} {$p+f_a^1=11\cdot67$ in B.F. section} $f_a=6\cdot26$ tons/in²	$N_a=1\cdot05$ $p^1=5\cdot49$ $f=13\cdot2$ $p+N_af_a=11\cdot6$	POSITION OF SPLICE M_f = Major axis yield moment $=62\cdot63(13\cdot2-5\cdot03)$ $=511$ tons-in $x=\frac{917-511}{917+467}\times12\cdot5$ $=3\cdot7$ft Say 4ft
SINGLE STOREY ROOF	$W_L=12\cdot1$ tons $W_T=17\cdot0$ tons $g=0\cdot29$ $l=33$ft	$M_p=367$ tons-in $S=24\cdot1$in³ 10in × 4½in × 25 lb I ($S=28\cdot1$) I = 122·3in⁴	$K_1=37\cdot2$ $K_2=\frac{122\cdot3}{33}=3\cdot7$ $Q_1=\frac{37\cdot2}{30\cdot1+32\cdot8}=0\cdot59$ $Q_2=\frac{3\cdot7}{30\cdot1+32\cdot8}=0\cdot06$	GROUND	$P=81\cdot1+\frac{76\cdot2}{2}+3\cdot5$ $-\frac{2}{10}\{\frac{14\cdot1+14\cdot1+42\cdot3}{2}\}$ $=122\cdot7-7\cdot0=115\cdot7$ tons $h=20$ft $h=240$in 12in × 12in × 83 lb B.F. I	$A=24\cdot41$in² $T=48\cdot2$ $p=4\cdot73$ tons/in²	$K=\frac{655\cdot3}{20}=32\cdot8$ $Z_e=109\cdot2$in³ $h/r_e=\frac{240}{5\cdot18}=46\cdot3$ $h/r_v=\frac{240}{3\cdot06}=78\cdot3$	Single curvature moment at bottom zero TOP $M_p\frac{K_L}{K_U+K_L}=1885\frac{32\cdot8}{30\cdot1+32\cdot8}$ $=968$ tons-in	$\beta=0$ $f_a^1=\frac{968}{109\cdot2}=8\cdot87$ $p+f_a^1=4\cdot73+8\cdot87$ $=13\cdot60$ $f_a=5\cdot01$ tons/in²	$N_a=1\cdot11$ $p^1=5\cdot25$ $f=14\cdot5$ $p+N_af_a=10\cdot3$	INTERNAL STANCHION $P=115\cdot7+\frac{17\cdot0}{2}=124\cdot2$ tons Section as external stanchion $p=5\cdot09$ tons/in² TOP $(M_{p1}-\frac{4}{3}gM_{p2})=1743$ tons-in $1743\times\frac{1}{1+Q_2}\times\frac{K_L}{K_U+K_L}=\frac{1743}{1\cdot06}$ $\times\frac{32\cdot8}{30\cdot1+32\cdot8}=858$ tons-in $\beta=0$ $f_a^1=7\cdot85$ $p+f_a^1=12\cdot94$ $f_a=4\cdot44$ $N_a=1\cdot12$ $p^1=5\cdot50$ $f=14\cdot4$ $p+N_af_a=10\cdot1$

TABLE III—*Calculation Sheet for Four-Storey Frame*

out-of-balance moment acting on the joint is thus $\left(M_{p2}-\frac{g_1 W_1 l_1}{12}\right)$, and this is called the "total clockwise moment" M_{TC} at the joint. It may alternately be expressed as

$$M_{TC}=M_{p2}-\frac{4}{3}g_1 M_{p1} \quad . \quad . \quad . \quad (3)$$

If, now, the joint E is unclamped, the moments induced at E in the stanchion lengths BE and EH will depend primarily on this total moment M_{TC}.

The first stage in designing the stanchion is thus to calculate the "total moments" at all the joints in a structure, and these figures are shown for the Cambridge building in Fig. 7. The clockwise total moment is obtained by assuming plasticity in the beam on the right of a joint, the beam to the left (if present) being assumed elastic and carrying dead load only. Conversely, the anti-clockwise total moment assumes plasticity on the left and elastic behaviour with dead load only on the right. In a single-bay building, or down an outside stanchion in a multi-bay frame, half of these moments will be negative.

In any design, the full plastic moments of the beams will be somewhat larger than the minimum required values. The assumption is made that the provision of a beam stronger than the required minimum will not weaken the resistance of the structure, and so the full plastic moment M_{p2} in equation (3) is the required minimum value and not necessarily the actual value. The symbol M_{p1} in equation (3) also refers to the least value. Thus, in Fig. 7 for joint G, we have

Clockwise total moment=

$$M_{TC}=1885 \text{ tons-inch.}$$

Anti-clockwise total moment=

$$M_{TA}=-\frac{4}{3}(0{\cdot}44)1885=-1106 \text{ tons-inch.}$$

For joint H we have

$$M_{TC}=367-\frac{4}{3}(0{\cdot}44)1885=-739 \text{ tons-inch.}$$

$$M_{TA}=1885-\frac{4}{3}(0{\cdot}29)367=1743 \text{ tons-inch.}$$

Having calculated the total moments at the joints in a structure, the loading condition for the stanchion may be determined. When at the ends of any stanchion length there exists a combination of positive clockwise total moment at one end, and positive anti-clockwise total moment at the other, it is possible for the stanchion to be bent in single curvature, as shown in Fig. 8. In this diagram we have for the stanchion length EH, at E,

$$M_{TA}=M_{p1}-\frac{4}{3}g_2 M_{p2}$$

and at H

$$M_{TC}=M_{p2}{}^1-\frac{4}{3}g_1{}^1 M_{p1}{}^1.$$

The stanchion moments M_{EB} and M_{EH} at joint E are calculated by assuming a joint rotation at E sufficient to achieve balance under the action of the total joint moment M_{TA}. Consider the general case of the moments M_U and M_L induced in the stanchion lengths above and below any joint as shown in Fig. 8 (*b*). In distributing the total joint moment $\left(M_{p1}-\frac{4}{3}g_2 M_{p2}\right)$ between the beam *ab* and the stanchions *ac* and *ad*, it is assumed that all these members are elastic, and that they have an effective stiffness obtained by assuming hinges at *b*, *c*, and *d*, as shown in the diagram. It is readily shown that

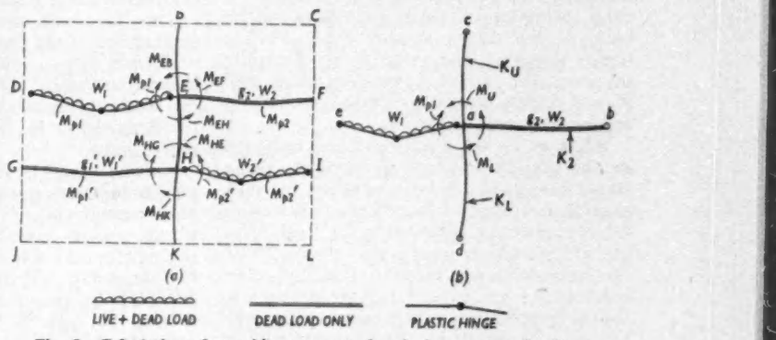


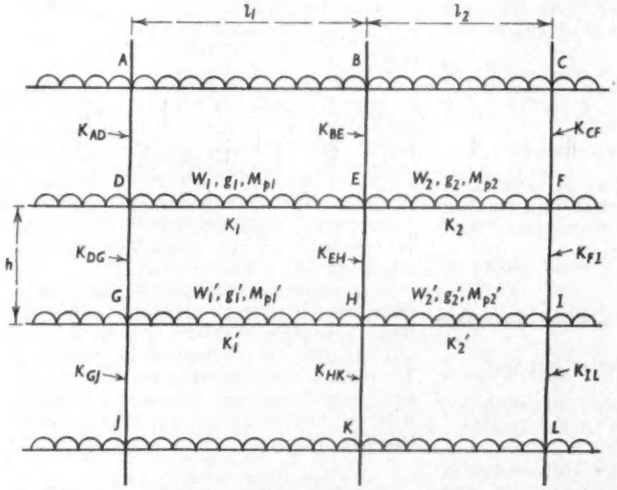
Fig. 8—Calculation of stanchion moments for single curvature bending

$$M_U+M_L=\frac{M_{p1}-\frac{4}{3}g_2 M_{p2}}{1+Q_2}=M_S \quad . \quad . \quad (4)$$

where

$$Q_2=\frac{K_2}{K_U+K_L}$$

and K_2, K_U and K_L denote stiffnesses (moment of inertia divided by length), as shown in Fig. 8 (*b*). The moment $M_S=M_U+M_L$ is



W_1, W_2 &c. Total factored loads.
g_1, g_2 &c. Dead load+total load
M_{p1}, M_{p2} &c. Minimum full plastic moment.
K_1, K_{AD} &c. Stiffnesses.

Fig. 6—Nomenclature for multi-storey, multi-bay frame

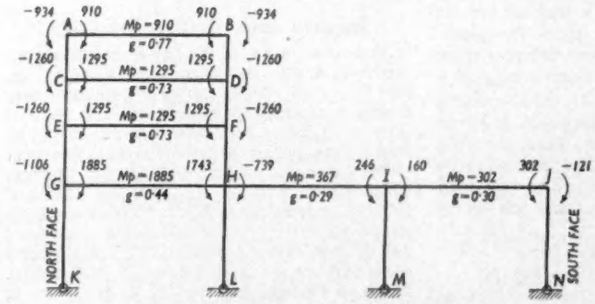
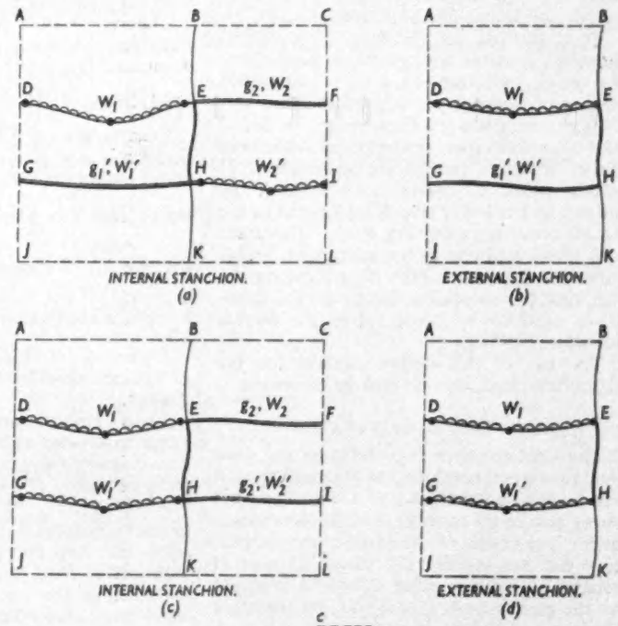


Fig. 7—Total joint moments (tons-inches)



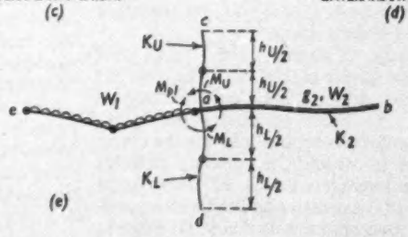


Fig. 9—Calculation of stanchion moments for double curvature bending

divided between the stanchions at a in the ratio of their stiffnesses—that is

$$M_U = \frac{K_U}{K_U + K_L} M_S \quad . \quad . \quad . \quad . \quad (5)$$

It will be noted that the total joint moments $\left(M_{p1} - \frac{4}{3} g_2 M_{p2}\right)$, &c., depend only on the loading on the frame. The stiffness ratios Q_2 and $\frac{K_U}{K_U + K_L}$ have, however, to be estimated. Usually it is possible to make reasonably close estimates of these quantities on the basis of the design already made for the higher storeys. The value of Q_2 generally decreases the further down a building, and $K_U = K_L$ unless there is a change of stanchion section or storey height.

When either the clockwise total moments or the anti-clockwise total moments for a stanchion length are both negative, the only possible condition of the stanchion is that of double curvature, as shown in Fig. 9 (a). Any outside stanchion length will always be in double curvature, as shown in Fig. 9 (b). The loadings in Figs. 9 (a) and 9 (b) are more severe for the respective stanchion lengths than those in Figs. 9 (c) and 9 (d). This is because μ (see Table II) and, hence f_x, is larger when β (the ratio of end moments in the stanchion) is near to zero than when it is near to -1. The total moment at a joint is distributed for the double curvature case by assuming the points of contraflexure shown in Fig. 9 (e), from which

$$M_U + M_L = \frac{M_{p1} - \frac{4}{3} g_2 M_{p2}}{1 + \frac{1}{2} Q_2} = M_S \quad . \quad (6)$$

The values of M_U and M_L are again calculated in the manner shown by equation (5). It may be noted that the single and double curvature cases differ only by the replacement of Q_2 for single curvature (equation (4)) by $\frac{1}{2} Q_2$ for double curvature (equation (6)).

This method of estimating stanchion moments (suitable for stanchions bent about the major axis only) is a much simplified version of methods previously described at a Symposium given in Cambridge in 1956.[4] The main difference as compared with these earlier methods lies in the assumption of central points of contraflexure in both the upper and the lower stanchion lengths in the double curvature case, Fig. 9 (e). This leads to a lower estimate of the maximum double curvature moment. This is justified by the fact that the stanchion design curves themselves tend to be conservative for double curvature bending.

The use of this design method for the Cambridge building will now be described.

Main Design Calculations

The steel structure was designed for dead load plus worst combination of superimposed live loads at a load factor of 1·75. The yield stress was in all cases 15·25 tons per square inch. The design of the single-storey laboratory did not include any novel features in relation to many existing structures designed by the plastic theory, and will not therefore be described in any detail.

As already described, the total joint moments are given in Fig. 7. The detailed design calculations are reproduced in Table III. In order to clarify the working, the calculations reproduced are the check calculations in which the various stiffness ratios were already known. In the original design, the stiffness ratios had to be estimated.

The first two columns in Table III refer to the design of the beams, and columns 3 to 10 refer to the stanchions. The stanchion calculations shown in columns 3 to 9 are those for the north face (Fig. 7), in which the complication of the single-storey laboratory is avoided. The stanchion sections on the south face were all identical with those on the north, the loading on the roof of the single-storey laboratory being too light to make any significant contribution to the stanchion load. However, in order that the method of designing a two-bay frame may be illustrated, the check calculations for the bottom stanchion length HL (Fig. 7) are summarised at the foot of column 10.

The following notes are provided in explanation of the design calculations.

Column (1).—(1) Live load in tons per beam (factored); (2) Total load in tons; (3) Ratio of dead load to total load $= g$; (4) Beam span in feet (between stanchion centre lines).

Column (2).—(1) Required minimum full plastic moment (tons-inch); (2) Required plastic modulus; (3) Section chosen, with actual plastic modulus; (4) Moment of inertia of actual section.

Column (3).—(1) Stiffness of beam to left of joint (moment of inertia in (inches)^4 divided by span in feet); (2) Stiffness of beam to right of joint; (3) Stiffness ratio $Q_1 = \frac{K_1}{K_U + K_L}$ where K_U and K_L denote stiffnesses of stanchion lengths above and below the joint; (4) Stiffness ratio $Q_2 = \frac{K_2}{K_U + K_L}$.

Column (4).—(1) The axial load P in the stanchion. This is calculated on the assumption that all floors carry their full live load, but a reduction is made for stanchions supporting two or more floors, the reductions being the same as those allowed in clause 8 of B.S. 449 (1948). A load of 3·5 tons is added for walls at each storey; (2) Height of stanchion length (between beam centres) in feet; (3) Height in inches (h); (4) Section used for stanchion length.

Column (5).—(1) Area of cross section of stanchion (A square inches); (2) Torsion constant T (see references 2 and 3); (3) Mean axial stress $p = \frac{P}{A}$ (tons per square inch).

Column (6).—(1) Stiffness of stanchion; (2) Elastic modulus of stanchion for bending about major axis; (3) Slenderness about major axis $\left(\frac{l}{r_x}\right.$ where r_x = larger radius of gyration$\left.\right)$; (4) Slenderness about minor axis $\left(\frac{l}{r_y}\right.$ where r_y = smaller radius of gyration$\left.\right)$.

Column (7).—This contains the calculation of the terminal moments in the stanchion lengths.

Third Floor Stanchion.—This carries a small axial load only and is therefore most conveniently designed to develop full plasticity at the top of the frame where it supports the roof beam. The special design curves given in Volume II of *The Steel Skeleton*[3] are used for this purpose. The top bending moment of 1090 tons-inch is the full plastic moment of the stanchion under the given axial load. Since this moment is larger than the minimum full plastic moment required in the roof beam (910 tons-inch), the stanchion is sufficiently strong in bending. In order to check the stability of the stanchion, the minimum moment at its lower end must be obtained, so that the third floor carries dead load only. The bottom total stanchion moment becomes

$$\left(\frac{4}{3} g M_p\right) \frac{1}{1 + \frac{1}{2} Q} = \frac{1260}{1 + \frac{1}{2} Q} \quad \text{(see Fig. 7)}$$

and this is divided between the second and third floor stanchion lengths in proportion to their stiffnesses.

Second Floor Stanchion.—The loading condition for this length is less severe than that of the length below and so need not be checked.

First Floor Stanchion. — This stanchion length contains a splice 4ft above the first floor beam, but bending moments are calculated as for a stanchion with the smaller section throughout. The critical loading condition is for double curvature with the larger moment at the bottom, since the first floor is more heavily loaded than the second. The total joint moment at the top is $\frac{4}{3} g M_p =$ 1260 tons-inch, while that at the bottom is $M_p = 1885$ tons-inch.

Ground Floor Stanchion.—The base of the stanchion is assumed to be hinged, whence $\beta = 0$. The total joint moment at the top ($M_p = 1885$ tons-inch) is divided between the upper and lower stanchion lengths in proportion to their stiffnesses.

Column (8).—(1) Ratio of terminal bending moments β; (2) Bending stress f_x^1 due to larger terminal moment. In the case of the first floor stanchion, which contains a splice, the bending stress of 14·70 tons per square inch for the lower end of the stanchion is fictitious, and the value in parentheses (8·40 tons per square inch) is the actual value; (3) Greatest terminal stress $p + f_x^1$. This must not exceed 15·25 tons per square inch; (4) The equivalent uniform bending stress f_x, obtained as $f_x = \mu f_x^1$ where μ depends on β as shown in Table II.

Column (9).—(1) The value of N_x obtained from p and $\frac{l}{r_x}$, using Fig. 5 (b); (2) $p^1 = p + \frac{f_x^2}{T}$; (3) The value of f, obtained from p^1 and $\frac{l}{r_y}$, using Fig. 5 (a); (4) $(p + N_x f_x)$. For stability, this must not exceed the value of f.

Column (10).—The position of the splice in floor 1 is obtained by ensuring that the yield stress is not exceeded in the smaller section. The allowable major axis bending stress at the splice section is given by

$$M_f = Z_x(f - p) = 62 \cdot 63(13 \cdot 2 - 5 \cdot 03) = 511 \text{ tons-inch.}$$

The position of the splice may thus be calculated.

At the bottom of column 10, the calculations for the internal stanchion length HL (Fig. 7) are given. The stiffness ratios Q_1, and Q_2 are given at the bottom of column 3. The bottom stanchion moment is, of course, zero, while the top moment is obtained from the total joint moment 1743 tons-inch (see Fig. 7).

References

[1] The Engineer, February 28, 1958, page 330.
[2] Horne, M. R., "The Stanchion Problem in Frame Structures Designed According to Ultimate Carrying Capacity" *Proc. Inst. Civ. Engrs.*, Part III, Vol. 5 (1956), page 105.
[3] Baker, J. F., Horne, M. R., and Heyman, J., *The Steel Skeleton*, Vol. II, C.U.P., 1956, Chapter 15.
[4] Horne, M. R., "Multi-Storey Frames," *British Welding Journal*, Vol. 3 (1956), page 336.

(*To be continued*)

Inquiry into Bridge Disaster

As a consequence of the failure of the Second Narrows Bridge at Vancouver, Canada, on June 17, 1958, when, during its erection, two almost completed spans fell into the Burrard Inlet, a Royal Commission inquiry is to be held. Through Sir Arthur Whitaker, President of the Institution of Civil Engineers in London, Chief Justice Lett of the Supreme Court of British Columbia asked that two British engineers should act in the roles of engineering consultants and advisers on the Commission. The engineers concerned are Mr. Ralph Freeman, of Freeman, Fox and Partners and Mr. J. R. H. Otter, of Rendel, Palmer and Tritton.

Creep Under Changing Complex Stress Systems

By A. E. JOHNSON, D.Sc., M.Sc.Tech., M.I.Mech.E., J. HENDERSON, B.Sc., and V. MATHUR, B.Sc.

No. I

In previously published work the authors have established on an experimental basis, creep rate-stress-time relations which adequately described the behaviour of a number of engineering materials at practical working temperatures under conditions of complex stress where the complex stress system remained unaltered throughout the course of creep. However, in engineering practice, in general the stress system causing creep may alter during the course of creep, and it is necessary to generalise the creep rate-complex stress-time relations to cover such cases. The present work has determined such generalised relations for a 0·2 per cent carbon steel at 450 deg. Cent., an aluminium alloy RR59 at 150 deg. and 200 deg. Cent. and a magnesium alloy (2 per cent aluminium) at 20 deg. and 50 deg. Cent. The experimental data have also been compared with the predictions of the various mechanical theories of creep, and the likely degree of correctness of these latter assessed.

IN a series of papers by one of the authors, the subject of the complex stress creep of metallic alloys at elevated temperatures was considered for the case of "simple" loading conditions, i.e. conditions in which the imposed complex stress system is maintained unaltered throughout the complex stress creep test.

Data from an extensive series of such tests made on a 0·2 per cent carbon steel at 350 deg. and 450 deg. Cent., on aluminium alloy (RR59) at 150 deg. and 200 deg. Cent., a magnesium (2 per cent aluminium) alloy at 20 deg. and 50 deg. Cent., and Nimonic 75 material at 550 deg. and 650 deg. Cent. were analysed, and equations relating creep rate, stress, and time established for these materials and temperatures. These equations related to the primary stage of creep.

A number of conclusions relating to the materials in question were reached, and in view of the importance and relevance of these conclusions to the theme of the current paper, they are briefly outlined below.

(1) Over a considerable range of stress, and time, all primary creep curves for a given alloy at a specific temperature, were geometrically similar whatever the nature of the stress system.

(2) Hydrostatic stress had no effect upon the magnitude of creep strain.

(3) Up to moderate stress levels material initially isotropic remained isotropic, and up to this stress level creep rates were well represented by relations of the form

$$C_{ij} = F(J_2)(S_{ij})\phi(t)$$

where $F(J_2)$ is a simple power function of the second stress invariant, the exponent of this power function varying only little among the various metallic alloys and temperatures. S_{ij} is of course the stress deviation and $\phi(t)$ a simple power function of time.

(4) At higher stress levels anisotropy was acquired by the alloys as a result of initial plastic and creep strain, this apparently being of a relatively simple, and similar, type for all alloys at all temperatures concerned except for the case of the magnesium alloy at 50 deg. Cent., where a somewhat more complex system of anisotropy arose. At such stress levels the function $F(J_2)$ became a compound power function of an anisotropic nature.

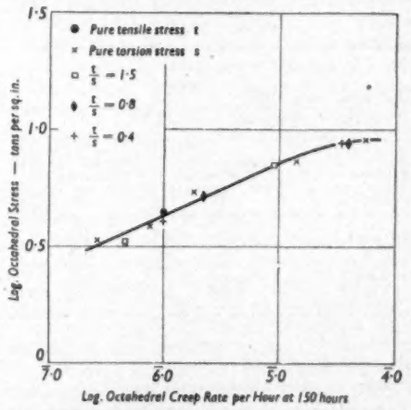
(5) Despite the facts indicated under (4) the relations at all stress levels could be expressed by the equation quoted under (3) providing that the $F(J_2)$, and S_{ij} were read as complex and/or anisotropic terms at the higher levels of stress.

Now although the relations derived above have application to many practical conditions where complex stress creep occurs, there are other cases in practice where creep under complex stress systems occurs, but where also the complex stress system changes during the course of creep. Accordingly it is essential for adequate analysis of the most general practical cases of complex stress creep, that the complex stress creep rate-time-stress equations be established for metallic alloys under general loading conditions.[1] These conditions are simulated when the loading giving rise to the complex stress system of a creeping test piece is changed periodically during the course of a creep test. Such tests are described in the current paper, which further seeks to establish generalised versions of the creep rate-time-stress equations to account adequately for the behaviour noted in the tests.

Materials Used in the Investigation

Three materials were made use of in this work, namely a 0·2 per cent carbon steel at 450 deg. Cent. (not the one previously used in the simple loading complex stress creep tests quoted in previous paragraphs), RR59 aluminium alloy at 150 deg. and 200 deg. Cent., and a magnesium alloy (2 per cent aluminium) at 20 deg. and 50 deg. Cent. The two latter materials were used in the simple loading complex stress creep tests already referred to, and the simple loading complex stress creep properties of the 0·2 per cent carbon steel at 450 deg. Cent. were specially obtained for use in the currently described general loading tests. Relevant

[1] The term "general loading" in the most general sense includes the so-called "spectrum loading." In the present paper, however, the conditions are such that no unloading occurs during the course of a test, all tests being loaded to a progressively increasing stress level.


Pure tensile stress t
Pure torsion stress s
t/s = 1·5
t/s = 0·8
t/s = 0·4
Log. Octahedral Stress — tons per sq. in.
Log. Octahedral Creep Rate per Hour at 150 hours

Curve corresponds with principal plane equations of nature :

$$C_1 = [2{\cdot}2\times10^{-5}\{\Sigma(\sigma_1-\sigma_2)^2\}^{1\cdot02s} + 7{\cdot}4\times10^{-15}\{\Sigma(\sigma_1-\sigma_2)^2\}^{2\cdot50}] \times[(\sigma_1-\sigma_\phi)-(\sigma_3-\sigma_1)]t^{-0\cdot7}$$

where σ_1, σ_3 and σ_2 are principal stresses and t is time.

Fig. 1—Simple loading complex stress creep tests on 0·2 per cent C steel at 450 deg. Cent. Log octahedral stress-log octahedral creep rate curve for the period of test 150 hours

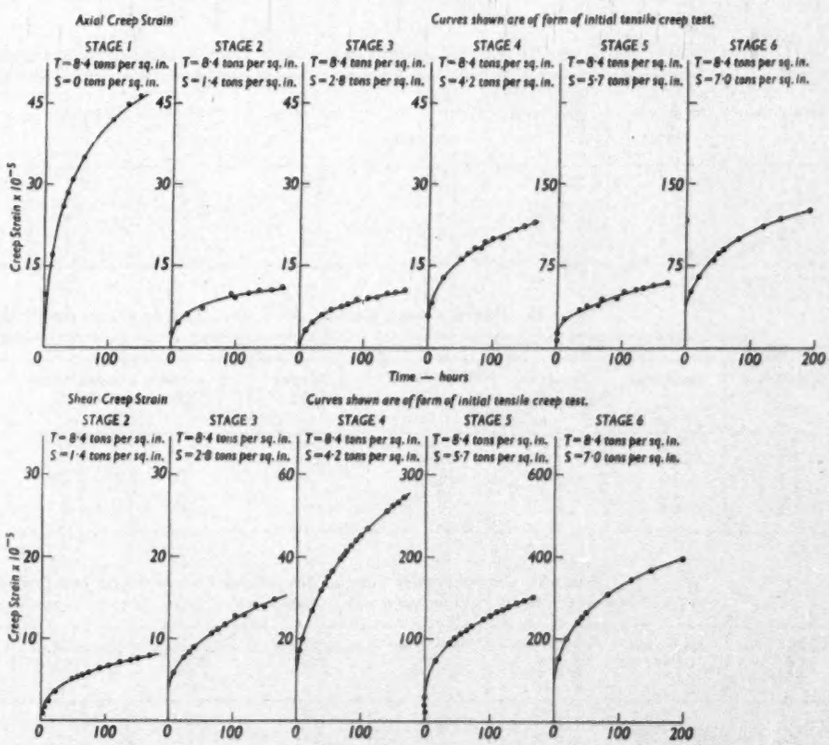

Axial Creep Strain
Curves shown are of form of initial tensile creep test.
STAGE 1 T=8·4 tons per sq. in. S=0 tons per sq. in.
STAGE 2 T=8·4 tons per sq. in. S=1·4 tons per sq. in.
STAGE 3 T=8·4 tons per sq. in. S=2·8 tons per sq. in.
STAGE 4 T=8·4 tons per sq. in. S=4·2 tons per sq. in.
STAGE 5 T=8·4 tons per sq. in. S=5·7 tons per sq. in.
STAGE 6 T=8·4 tons per sq. in. S=7·0 tons per sq. in.
Creep Strain x 10⁻⁵
Time — hours
Shear Creep Strain
Curves shown are of form of initial tensile creep test.
STAGE 2 T=8·4 tons per sq. in. S=1·4 tons per sq. in.
STAGE 3 T=8·4 tons per sq. in. S=2·8 tons per sq. in.
STAGE 4 T=8·4 tons per sq. in. S=4·2 tons per sq. in.
STAGE 5 T=8·4 tons per sq. in. S=5·7 tons per sq. in.
STAGE 6 T=8·4 tons per sq. in. S=7·0 tons per sq. in.
Creep Strain x 10⁻⁵
Time — hours

Fig. 2—General loading complex stress creep tests on 0·2 per cent C steel at 450 deg. Cent. : initial tensile stress 8·4 tons per square inch. Stage period 167 hours

TABLE I—*Details of Production, Heat-Treatment and Chemical Composition of Materials*

Material	Details of production and dimensions	Details of heat-treatment	Details of chemical composition, per cent									
			Carbon	Silicon	Sulphur	Phosphorus	Nickel	Chromium	Molybdenum	Copper	Tin	Manganese
Carbon steel	Core from an ingot. Diameter 16in. Length 34½in.	Soaked for 4 hours at 840/850 deg. Cent., drawn and air cooled as uniformly as possible; reheated to 580/600 deg. Cent. and soaked for 4 hours. Cooled slowly in furnace	0·24	0·22	0·036	0·033	0·27	0·09	0·03	0·16	0·005	0·69
Aluminium alloy ...	Billets 18in long, and 12in in diameter, continuous cast	528 deg. Cent. ±5 deg. Cent. for 8 hours and quenched in boiling water. 24 hours at room temperature, heated at 170 deg. Cent. for 16 hours and air cooled	To D.T.D. specification for this alloy									
			Zinc	Aluminium	Silicon	Copper	Manganese	Iron	Tin	Magnesium remainder		
Magnesium alloy ...	Billets of length 12in and diameter 12in	420 deg. Cent. ±5 deg. Cent. for 4 hours, furnace cooled to room temperature in about 10 hours. Heat treatment carried out in an atmosphere of sulphur dioxide	<0·05	2·0	0·02	<0·01	0·03	<0·04	<0·03			

TABLE II

Values of the constants A_1, A_2, p_1, p_2, and m in the equations

Axial Creep Rate $Ca = 2/3\,[A_1(J_2)^{p_1} + A_2(J_2)^{p_2}]Tr^{-m}$

Shear Creep Rate $Cc = 2\,[A_1(J_2)^{p_1} + A_2(J_2)^{p_2}]Sr^{-m}$

for various materials, and temperatures

Material	Temperature deg. Cent. of creep test	Stress t.s.i. in creep test	Period of stage in creep test, hours	A_1	A_2	p_1	p_2	m
0·2 per cent carbon steel	450 deg. Cent.	8·4	167	$1·03\times10^{-7}$	$1·55\times10^{-31}$	$1·22_8$	3·25	$0·70_9$
0·2 per cent carbon steel	450 deg. Cent.	7·2	167	$9·4\times10^{-8}$	$1·42\times10^{-31}$	$1·22_8$	3·25	$0·70_9$
0·2 per cent carbon steel	450 deg. Cent.	7·2	24	$1·78\times10^{-7}$	$2·7\times10^{-31}$	$1·22_8$	3·25	0·68
0·2 per cent carbon steel	450 deg. Cent.	6·0	167	$2·5\times10^{-9}$	$4·23\times10^{-31}$	$1·22_8$	3·25	$0·77_8$
Aluminium (RR59) alloy	150 deg. Cent.	5·0	167	$2·5\times10^{-6}$	$3·35\times10^{-15}$	0	5·0	0·67
Aluminium (RR59) alloy	150 deg. Cent.	5·0	24	$1·34\times10^{-6}$	$1·79\times10^{-15}$	0	5·0	0·5
Aluminium (RR59) alloy	150 deg. Cent.	4·0	167	$9·5\times10^{-7}$	$1·44\times10^{-15}$	0	5·0	0·43
Aluminium (RR59) alloy	200 deg. Cent.	3·0	167	$2·04\times10^{-6}$	$9·62\times10^{-21}$	0·5	13·5	0·62
Aluminium (RR59) alloy	200 deg. Cent.	3·0 (repeat)	167	$2·14\times10^{-6}$	$9·75\times10^{-21}$	0·5	13·5	$0·63_4$
Magnesium (2 per cent aluminium) alloy ...	20 deg. Cent.	3·0	167	$4·1\times10^{-6}$	$5·2\times10^{-6}$	0·5	3	0·8
Magnesium (2 per cent aluminium) alloy ...	20 deg. Cent.	3·0	24	4×10^{-6}	$5·1\times10^{-6}$	0·5	3	$0·74_0$
Magnesium (2 per cent aluminium) alloy ...	20 deg. Cent.	1·35	167	$6·8\times10^{-8}$	$8·6\times10^{-6}$	0·5	3	$0·77_8$
Magnesium (2 per cent aluminium) alloy ...	50 deg. Cent.	2·0	167	$11·43\times10^{-6}$	$11·68\times10^{-9}$	$0·21_8$	0·5	$0·66_8$
Magnesium (2 per cent aluminium) alloy ...	50 deg. Cent.	1·5	167	$9·63\times10^{-8}$	$9·75\times10^{-9}$	$0·21_8$	0·5	0·72

TABLE III—*General Loading Complex Stress Creep Tests on 0·2 per cent Carbon Steel at 450 deg. Cent.*

Tests from initial tensile stress of 8·4 tons per square inch. Stage period 167 hours. Creep rates measured at 150 hours. Creep strains at end of test

Tensile stress T t.s.i.	Shear stress S t.s.i.	Axial creep rate $\times10^{-6}$/hr. Ca	Shear creep rate $\times10^{-6}$/hr. Cc	Axial creep strain $\times10^{-4}$ e_a	Shear creep strain $\times10^{-4}$ e_s	Octahedral creep strain $\times10^{-4}$ e_0	Integrated axial creep strain in previous tests $\times10^{-4}$	Integrated shear creep strain in previous tests $\times10^{-4}$	Integrated octahedral creep strain in previous tests $\times10^{-4}$
8·4	0	0·9	—	4·7	—	6·6	—	—	—
8·4	1·4	0·21	0·13	1·05	0·93	2·59	4·7	—	6·6
8·4	2·8	0·23	0·33	1·06	1·5	2·22	5·75	0·93	9·2
8·4	4·2	0·48	1·0	2·32	5·5	6·44	6·8	2·43	11·4
8·4	5·7	1·38	2·75	6·0	15·2	15·5	9·12	7·93	17·9
8·4	7·0	2·6	7·3	12·0	3·7	35·3	15·1	23·1	33·4

TABLE IV—*General Loading Complex Stress Creep Tests on 0·2 per cent Carbon Steel at 450 deg. Cent.*

Test from initial tensile stress of 7·2 tons per square inch. Stage period 167 hours. Creep rates measured at 150 hours. Creep strains at end of test

Tensile stress T t.s.i.	Shear stress S t.s.i.	Axial creep rate $\times10^{-6}$/hr. Ca	Shear creep rate $\times10^{-6}$/hr. Cc	Axial creep strain $\times10^{-4}$ e_a	Shear creep strain $\times10^{-4}$ e_s	Octahedral creep strain $\times10^{-4}$ e_0	Integrated axial creep strain in previous tests $\times10^{-4}$	Integrated shear creep strain in previous tests $\times10^{-4}$	Integrated octahedral creep strain in previous tests $\times10^{-4}$
7·2	0	$0·37_0$	—	2·43	—	3·43	—	—	—
7·2	1·2	$0·17_6$	0·09	0·32	0·6	2·25	2·43	—	3·43
7·2	2·4	0·21	0·21	1·16	1·34	2·01	2·75	0·6	5·68
7·2	3·6	0·28	0·42	1·5	2·3	2·76	3·91	1·94	7·69
7·2	4·8	0·35	0·70	1·9	4·85	5·0	5·41	4·24	10·45
7·2	6·0	0·88	2·2	3·8	12·0	11·4	7·31	9·09	15·45

TABLE V—*General Loading Complex Stress Creep Tests on 0·2 per cent Carbon Steel at 450 deg. Cent.*

Test from initial tensile stress of 6 tons per square inch. Stage period 167 hours. Creep rates measured at 150 hours. Creep strains at end of test

Tensile stress T t.s.i.	Shear stress S t.s.i.	Axial creep rate $\times10^{-6}$/hr. Ca	Shear creep rate $\times10^{-6}$/hr. Cc	Axial creep strain $\times10^{-4}$ e_a	Shear creep strain $\times10^{-4}$ e_s	Octahedral creep strain $\times10^{-4}$ e_0	Integrated axial creep strain in previous tests $\times10^{-4}$	Integrated shear creep strain in previous tests $\times10^{-4}$	Integrated octahedral creep strain in previous tests $\times10^{-4}$
6	0	0·42	—	3·0	—	4·25	—	—	—
6	1	0·21	0·08	0·45	0·5	1·54	3·0	—	4·25
6	2	0·18	0·12	0·53	0·76	1·12	3·45	0·50	5·79
6	3	0·14	0·2	0·57	1·22	1·41	3·98	1·25	6·91
6	4	0·15	0·34	0·86	2·24	2·28	4·55	2·47	8·32
6	5	0·17	$0·42_0$	1·16	3·5	3·33	5·41	4·71	10·6

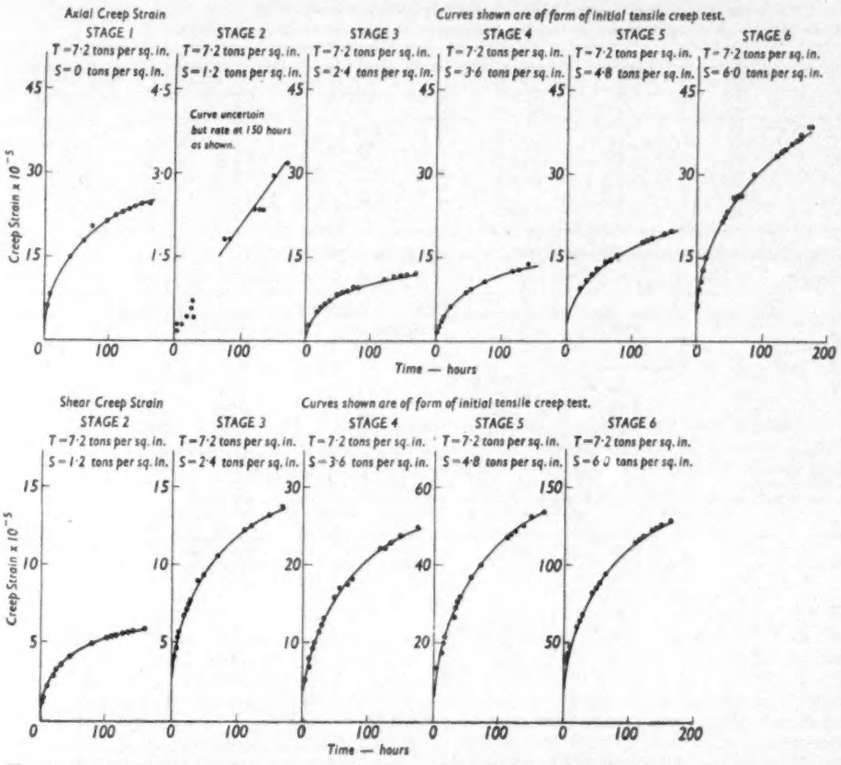

Axial Creep Strain
Curves shown are of form of initial tensile creep test.
STAGE 1
T=7·2 tons per sq. in.
S=0 tons per sq. in.
STAGE 2
T=7·2 tons per sq. in.
S=1·2 tons per sq. in.
STAGE 3
T=7·2 tons per sq. in.
S=2·4 tons per sq. in.
STAGE 4
T=7·2 tons per sq. in.
S=3·6 tons per sq. in.
STAGE 5
T=7·2 tons per sq. in.
S=4·8 tons per sq. in.
STAGE 6
T=7·2 tons per sq. in.
S=6·0 tons per sq. in.
Curve uncertain but rate at 150 hours as shown.
Creep Strain x 10⁻⁵
Time — hours
Shear Creep Strain
Curves shown are of form of initial tensile creep test.
STAGE 2
T=7·2 tons per sq. in.
S=1·2 tons per sq. in.
STAGE 3
T=7·2 tons per sq. in.
S=2·4 tons per sq. in.
STAGE 4
T=7·2 tons per sq. in.
S=3·6 tons per sq. in.
STAGE 5
T=7·2 tons per sq. in.
S=4·8 tons per sq. in.
STAGE 6
T=7·2 tons per sq. in.
S=6·0 tons per sq. in.
Creep Strain x 10⁻⁵
Time — hours

Fig. 3—General loading complex stress creep tests on 0·2 per cent C steel at 450 deg. Cent. : initial tensile stress 7·2 tons per square inch. Stage period 167 hours

details of the preparation of these materials are given in Table I.

Table II gives a list of constants occurring in the simple loading complex stress creep equations characteristic of these materials for the axial and shear creep rates of a thin walled tubular specimen loaded by one tension and one torsion stress as in the current creep tests. The constants actually correspond in detail to individual test pieces used in the tests concerned, but are based in all cases upon the general, and average creep equations derived for the various materials in the extensive simple loading tests already referred to in previous paragraphs. Deviation of the individual specimen condition from the average of the material, is reflected mainly in the arithmetical coefficients A1 and A2 prefixing stress terms of the creep equations. It should be stated that the object of using actual creep equations of the initial tensile creep test of general loading tests was simply increased accuracy of comparison with later stages of such tests, since, of course, in general it is possible that the deviation in the tensile creep test of an individual specimen from the average for that material, may be of the same order as the difference between the initial tensile creep test characteristics, and those of subsequent tests.

Where anisotropy of these materials arose as a result of creep strain, the characteristics of this anisotropy were well known from the simple loading creep tests, and it was possible to allow for their effects in the various issues arising in the current research. However, in fact the incidence of such anisotropy in the current tests was small, and in relation to the nature of the issues arising in the paper, comparatively trivial.

Experimental Procedure

The tests were carried out in the same combined tensile and torsion creep units as were used in the simple loading complex stress creep tests, and experimental conditions were just as in those tests, the specimen used being of 0·5in internal diameter, and 0·02in or 0·03in wall thickness, and 2in gauge length. The degree of temperature control achieved was of the order ±0·5 deg. Cent., with thermal gradient along the specimen of not more than 3 deg. Cent. To achieve the objects of the tests a means of changing the stress system simply, and with a minimum of disturbance was required. This means was found by commencing a series of tests with a pure tensile creep test, and then adding at chosen intervals of time (approximately equal) suitable increments of torsion load to the (single) torsion scale pan. It was, in fact, found that virtually zero initial plastic strain occurred on adding the torsion increments chosen for all tests and stages. The analysis of results was accordingly unhampered by the consideration of the superimposed effects of time independent plastic strain. The actual order of the elements of torsion increments added to the initial tensile stress is indicated in Tables III to XVI. The choice of the order was largely determined by consideration of the likely magnitude of the ensuing creep strain based upon information derived from the simple loading creep test data available.

In nearly all tests a period of seven days (167 hours) was adopted for the length of the stage of each test under a particular current stress system, but in a small number of tests a stage period of one day (twenty-four hours) was adopted, for a special purpose. In these two varieties of test, comparisons of behaviour in individual stages were made on the basis of creep rates measured at 150 and twenty hours respectively.

In order to interpret and analyse the creep test data some means of comparison between the creep strains and rates arising in the various tests was required which was basically unaltered in kind by the changing principal stresses and rotating principal axes arising in the tests. Such a mode of comparison was available in the measured axial strain of the test piece, and the measured shear creep strain in the plane at right angles to the axis of the test piece. In view of the rotation of the principal and octahedral planes during the successive stages of the tests, no continuous comparison could be made on the basis of principal or octahedral rates or strains on a single plane for all stages.

Scope of the Experimental Work

Since the currently described complex stress creep work on metallic alloys constituted an entry into a field in which no

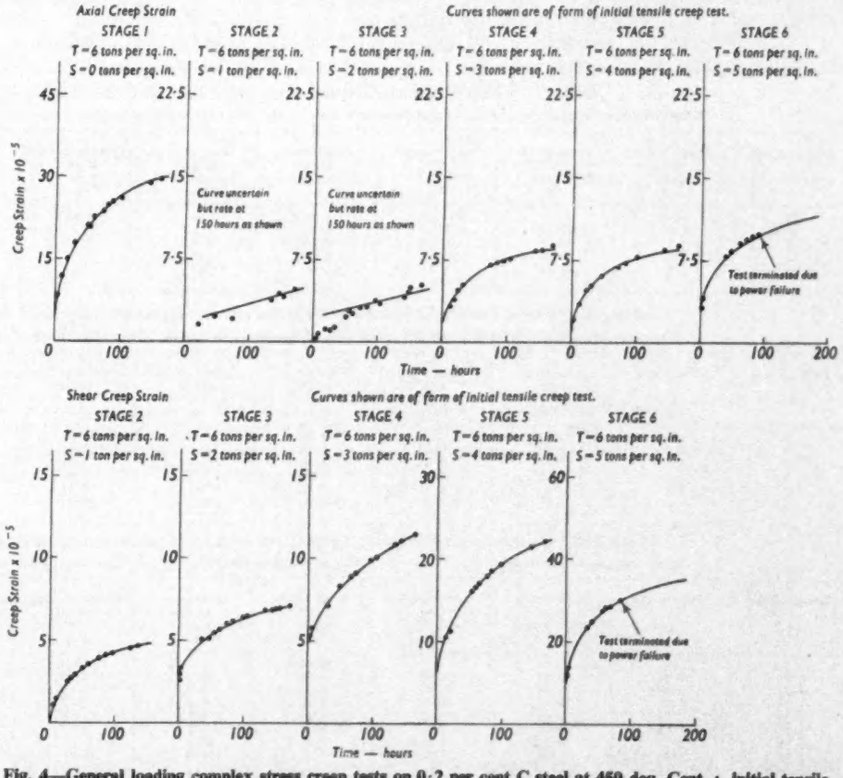

Axial Creep Strain
Curves shown are of form of initial tensile creep test.
STAGE 1
T=6 tons per sq. in.
S=0 tons per sq. in.
STAGE 2
T=6 tons per sq. in.
S=1 ton per sq. in.
STAGE 3
T=6 tons per sq. in.
S=2 tons per sq. in.
STAGE 4
T=6 tons per sq. in.
S=3 tons per sq. in.
STAGE 5
T=6 tons per sq. in.
S=4 tons per sq. in.
STAGE 6
T=6 tons per sq. in.
S=5 tons per sq. in.
Curve uncertain but rate at 150 hours as shown
Test terminated due to power failure
Creep Strain x 10⁻⁵
Time — hours
Shear Creep Strain
Curves shown are of form of initial tensile creep test.
STAGE 2
T=6 tons per sq. in.
S=1 ton per sq. in.
STAGE 3
T=6 tons per sq. in.
S=2 tons per sq. in.
STAGE 4
T=6 tons per sq. in.
S=3 tons per sq. in.
STAGE 5
T=6 tons per sq. in.
S=4 tons per sq. in.
STAGE 6
T=6 tons per sq. in.
S=5 tons per sq. in.
Test terminated due to power failure
Creep Strain x 10⁻⁵
Time — hours

Fig. 4—General loading complex stress creep tests on 0·2 per cent C steel at 450 deg. Cent. : initial tensile stress 6·0 tons per square inch. Stage period 167 hours

TABLE VI—*General Loading Complex Stress Creep Tests on 0·2 per cent Carbon Steel at 450 deg. Cent.*

Test from initial tensile stress of 7·2 tons per square inch. Stage period 24 hours. Creep rates measured at 20 hours. Creep strains at end of test

Tensile stress T t.s.i.	Shear stress S t.s.i.	Axial creep rate $\times 10^{-6}$/hr. Ca	Shear creep rate $\times 10^{-6}$/hr. Cc	Axial creep strain $\times 10^{-4}$ ε_a	Shear creep strain $\times 10^{-4}$ ε_c	Octahedral creep strain $\times 10^{-4}$ ε_o	Integrated axial creep strain in previous tests $\times 10^{-4}$	Integrated shear creep strain in previous tests $\times 10^{-4}$	Integrated octahedral creep strain in previous tests $\times 10^{-4}$
7·2	0	4·05	—	2·61	—	3·65	—	—	—
7·2	1·2	1·5	0·75	0·45	0·55	1·76	2·61	—	3·65
7·2	2·4	1·5	1·65	0·67$_5$	1·2	1·86	3·06	0·55	5·41
7·2	3·6	1·8	2·8	1·11	2·08	2·4	3·74	1·75	7·27
7·2	4·8	2·2	5·6	1·38	3·6	3·65	4·78	3·83	9·67
7·2	6·0	3·9	10·0	2·55	7·8	7·35	5·12	7·43	13·3
7·2	7·2	7·5	23·0	4·50	15·3	14·0	7·67	15·2	20·7

TABLE VII—*General Loading Complex Stress Creep Tests on RR59 (Aluminium Alloy) at 150 deg. Cent.*

Test from initial tensile stress of 5 tons per square inch. Stage period 167 hours. Creep rates measured at 150 hours. Creep strains at end of test

Tensile stress T t.s.i.	Shear stress S t.s.i.	Axial creep rate $\times 10^{-6}$/hr. Ca	Shear creep rate $\times 10^{-6}$/hr. Cc	Axial creep strain $\times 10^{-4}$ ε_a	Shear creep strain $\times 10^{-4}$ ε_c	Octahedral creep strain $\times 10^{-4}$ ε_o	Integrated axial creep strain in previous tests $\times 10^{-4}$	Integrated shear creep strain in previous tests $\times 10^{-4}$	Integrated octahedral creep strain in previous tests $\times 10^{-4}$
5	0	0·29	—	1·05	0	1·44	—	—	—
5	10/12	0·26	0·12	0·93	0·43	1·38	1·05	—	1·44
5	15/12	0·18	0·15	0·60	0·50	0·96	1·95	0·43	2·82
5	20/12	0·20	0·22	0·63	0·72	1·11	2·55	0·93	3·78
5	25/12	0·23$_5$	0·3	0·97	1·25	1·71	3·20	1·65	4·89

TABLE VIII—*General Loading Complex Stress Creep Tests on RR59 (Aluminium Alloy) at 150 deg. Cent.*

Test from initial tensile stress of 4 tons per square inch. Stage period 167 hours. Creep rates measured at 150 hours. Creep strains at end of test

Tensile stress T t.s.i.	Shear stress S t.s.i.	Axial creep rate $\times 10^{-6}$/hr. Ca	Shear creep rate $\times 10^{-6}$/hr. Cc	Axial creep strain $\times 10^{-4}$ ε_a	Shear creep strain $\times 10^{-4}$ ε_c	Octahedral creep strain $\times 10^{-4}$ ε_o	Integrated axial creep strain in previous tests $\times 10^{-4}$	Integrated shear creep strain in previous tests $\times 10^{-4}$	Integrated octahedral creep strain in previous tests $\times 10^{-4}$
4	—	0·29$_5$	—	0·8	—	1·13	—	—	—
4	7/12	0·14$_5$	0·07	0·35	0·17	0·53	0·8	—	1·13
4	12/12	0·11	0·11$_5$	0·3	0·31	0·57	1·15	0·17	1·66
4	16/12	0·15$_5$	0·17	0·32	0·42	0·62	1·45	0·48	2·23
4	20/12	0·12	0·20	0·31	0·53	0·67	1·77	0·9	2·85
4	24/12	0·11$_5$	0·25	0·25	0·65	0·78	2·08	1·43	3·52
4	28/12	0·10$_5$	0·3	0·32$_5$	0·76	0·73	2·33	2·08	4·3

TABLE IX—*General Loading Complex Stress Creep Tests on RR59 (Aluminium Alloy) at 150 deg. Cent.*

Test from initial tensile stress of 5 tons per square inch. Stage period 24 hours. Creep rates measured at 20 hours. Creep strains at end of test

Tensile stress T t.s.i.	Shear stress S t.s.i.	Axial creep rate $\times 10^{-6}$/hr. Ca	Shear creep rate $\times 10^{-6}$/hr. Cc	Axial creep strain $\times 10^{-4}$ ε_a	Shear creep strain $\times 10^{-4}$ ε_c	Octahedral creep strain $\times 10^{-4}$ ε_o	Integrated axial creep strain in previous tests $\times 10^{-4}$	Integrated shear creep strain in previous tests $\times 10^{-4}$	Integrated octahedral creep strain in previous tests $\times 10^{-4}$
5	—	1·0	—	0·42	—	0·6	—	—	—
5	10/12	0·45	0·6	0·19	0·26	0·87	0·42	—	0·6
5	15/12	0·45	0·5$_5$	0·17	0·22	0·43	0·61	0·26	1·47
5	20/12	0·47	0·4	0·22	0·18	0·36	0·78	0·48	1·9
5	25/12	0·5	0·79	0·23	0·34	0·44	1·0	0·66	2·26

TABLE X—*General Loading Complex Stress Creep Tests on RR59 (Aluminium Alloy) at 200 deg. Cent.*

First test from initial tensile stress of 3 tons per square inch. Stage period 167 hours. Creep rates measured at 150 hours. Creep strains at end of test

Tensile stress T t.s.i.	Shear stress S t.s.i.	Axial creep rate $\times 10^{-6}$/hr. Ca	Shear creep rate $\times 10^{-6}$/hr. Cc	Axial creep strain $\times 10^{-4}$ ε_a	Shear creep strain $\times 10^{-4}$ ε_c	Octahedral creep strain $\times 10^{-4}$ ε_o	Integrated axial creep strain in previous tests $\times 10^{-4}$	Integrated shear creep strain in previous tests $\times 10^{-4}$	Integrated octahedral creep strain in previous tests $\times 10^{-4}$
3	—	0·31$_5$	—	1·1	—	1·6	—	—	—
3	1·0	0·1	0·25	0·39	1·33	2·6	1·0	—	1·6
3	1·5	0·16	0·55	0·63	1·8	2·2	1·49	1·33	4·2
3	2·0	0·22	0·65	0·85	2·7	2·8	2·12	3·13	6·4
3	3·0	1·0	6·55	3·5	23·0	2·2	3·0	5·83	9·2

TABLE XI—*General Loading Complex Stress Creep Tests on RR59 Aluminium Alloy at 200 deg. Cent.*

Second test from initial tensile stress of 3 tons per square inch. Stage period 167 hours. Creep rates measured at 150 hours. Creep strains at end of test

Tensile stress T t.s.i.	Shear stress S t.s.i.	Axial creep rate $\times 10^{-6}$/hr. Ca	Shear creep rate $\times 10^{-6}$/hr. Cc	Axial creep strain $\times 10^{-4}$ ε_a	Shear creep strain $\times 10^{-4}$ ε_c	Octahedral creep strain $\times 10^{-4}$ ε_o	Integrated axial creep strain in previous tests $\times 10^{-4}$	Integrated shear creep strain in previous tests $\times 10^{-4}$	Integrated octahedral creep strain in previous tests $\times 10^{-4}$
3	0	0·31	—	1·15	—	1·64	—	—	—
3	1·0	0·12$_5$	0·3	0·7	1·68	2·9	1·15	—	1·64
3	1·5	0·17	0·43$_5$	0·66	1·75	2·12	1·85	1·68	4·54
3	2·0	0·24	0·61	1·0	2·5	2·54	2·51	3·43	6·66
3	2·5	0·39	1·55	1·6	6·5	—	3·51	5·93	9·2

TABLE XII—*General Loading Complex Stress Creep Tests on Magnesium Alloy at 20 deg. Cent. (2 per cent Aluminium)*

Test from initial tensile stress of 3 tons per square inch. Stage period 167 hours. Creep rates measured at 150 hours. Creep strain at end of test

Tensile stress T t.s.i.	Shear stress S t.s.i.	Axial creep rate $\times 10^{-6}$/hr. Ca	Shear creep rate $\times 10^{-6}$/hr. Cc	Axial creep strain $\times 10^{-4}$ ε_a	Shear creep strain $\times 10^{-4}$ ε_c	Octahedral creep strain $\times 10^{-4}$ ε_o	Integrated axial creep strain in previous tests $\times 10^{-4}$	Integrated shear creep strain in previous tests $\times 10^{-4}$	Integrated octahedral creep strain in previous tests $\times 10^{-4}$
3	—	0·23	—	2·35	—	3·33	—	—	—
3	0·6	0·25$_5$	0·06	0·95	0·49	1·44	2·35	—	3·33
3	1·2	1·4$_5$	0·21	1·18	2·15	2·85	3·3	0·49	4·77
3	1·8	0·29	0·75	1·8	5·2	5·61	4·48	2·64	7·62
3	2·4	0·5	1·55	3·48	9·1	8·94	6·28	7·84	13·23
3	3·0	1·6	5·5	11·2	38·5	35·3	9·76	16·94	22·17

TABLE XIII—*General Loading Complex Stress Creep Tests on Magnesium Alloy at 20 deg. Cent. (2 per cent Aluminium)*

Tests from initial tensile stress of 1·35 tons per square inch. Stage period 167 hours. Creep rates measured at 150 hours. Creep strains at end of test

Tensile stress T t.s.i.	Shear stress S t.s.i.	Axial creep rate $\times 10^{-6}$/hr. Ca	Shear creep rate $\times 10^{-6}$/hr. Cc	Axial creep strain $\times 10^{-4}$ ε_a	Shear creep strain $\times 10^{-4}$ ε_c	Octahedral creep strain $\times 10^{-4}$ ε_o	Integrated axial creep strain in previous tests $\times 10^{-4}$	Integrated shear creep strain in previous tests $\times 10^{-4}$	Integrated octahedral creep strain in previous tests $\times 10^{-4}$
1·35	—	0·1	—	0·66	—	0·94	—	—	—
1·35	0·45	0·05	0·05	0·31	0·31	0·91	0·66	—	0·94
1·35	0·675	0·04	0·07	0·25	0·52	0·94	0·97	0·31	1·85
1·35	0·9	0·05$_5$	0·12$_5$	0·36	0·9	1·45	1·22	0·83	2·79
1·35	1·35	0·09	0·28	0·53	1·75	2·09	1·58	1·73	4·24
1·35	1·69	0·08	0·4	0·45	2·8	2·87	2·11	3·48	6·33
1·35	2·7	0·5$_5$	4·0	3·4	40·0	33·9	2·56	6·28	9·2
1·35	3·38	1·08	12·5	7·0	93·0	78·0	5·96	46·3	43·1

TABLE XIV—*General Loading Complex Stress Creep Tests on Magnesium Alloy at 20 deg. Cent (2 per cent Aluminium)*

Test from initial tensile stress of 3 tons per square inch. Stage period 24 hours. Creep rates measured at 20 hours. Creep strain at end of test

Tensile stress T t.s.i.	Shear stress S t.s.i.	Axial creep rate $\times 10^{-6}$/hr. Ca	Shear creep rate $\times 10^{-6}$/hr. Cc	Axial creep strain $\times 10^{-4}$ ε_a	Shear creep strain $\times 10^{-4}$ ε_c	Octahedral cepre strain $\times 10^{-4}$ ε_0	Integrated axial creep strain in previous tests $\times 10^{-4}$	Integrated shear creep strain in previous tests $\times 10^{-4}$	Integrated octahedral creep strain in previous tests $\times 10^{-4}$
3	—	1·5	—	1·43	—	2·01	—	—	—
3	0·6	1·0	1·1$_5$	0·8	0·96	2·4	1·43	—	2·01
3	1·2	1·2	2·0	1·0	2·1	2·8	2·23	0·96	4·4
3	1·8	2·7	5·5	2·28	5·6	5·9	3·23	3·06	7·28
3	2·4	4·5	12·0	5·1	15·2	14·7	5·51	8·66	13·2

TABLE XV—*General Loading Complex Stress Creep Tests on Magnesium Alloy at 50 deg. Cent.*

Test from initial tensile stress of 2 tons per square inch. Stage period of 167 hours. Creep rates measured at 150 hours. Creep strains at end of test

Tensile stress, T t.s.i.	Shear stress S t.s.i.	Axial creep rate $\times 10^{-6}$/hr. Ca	Shear creep rate $\times 10^{-6}$/hr. Cc	Axial creep strain $\times 10^{-4}$ ε_a	Shear creep strain $\times 10^{-4}$ ε_c	Octahedral creep strain $\times 10^{-4}$ ε_0	Integrated axial creep strain in previous tests $\times 10^{-4}$	Integrated shear creep strain in previous tests $\times 10^{-4}$	Integrated octahedral creep strain in previous tests $\times 10^{-4}$
2	—	0·57	—	2·63	—	3·68	—	—	—
2	0·4	0·33	0·25	0·99	1·03	2·42	2·63	—	3·68
2	0·8	0·36	0·5	1·47	2·65	3·5	3·62	1·03	6·1

TABLE XVI—*General Loading Complex Stress Creep Tests on Magnesium Alloy at 50 deg. Cent.*

Test from initial tensile stress of 1·5 tons per square inch. Stage period of 167 hours. Creep rates measured at 150 hours. Creep strains at end of test

Tensile stress, T t.s.i.	Shear stress S t.s.i.	Axial creep rate $\times 10^{-6}$/hr. Ca	Shear creep rate $\times 10^{-6}$/hr. Cc	Axial creep strain $\times 10^{-4}$ ε_a	Shear creep strain $\times 10^{-4}$ ε_c	Octahedral creep strain $\times 10^{-4}$ ε_0	Integrated axial creep strain in previous tests $\times 10^{-4}$	Integrated shear creep strain in previous tests $\times 10^{-4}$	Integrated octahedral creep strain in previous tests $\times 10^{-4}$
1·5	—	0·28	—	1·4	—	2·0	—	—	—
1·5	0·3	0·115	0·07	0·49	0·45	1·01	1·4	—	2·0
1·5	0·6	0·17	0·2	0·75	1·16	1·5	1·89	0·45	3·01

experimental work had apparently been performed, the programme of work was arranged as a survey of the characteristics of certain of the alloys which had been used in simple loading creep tests at their appropriate working temperature, with the idea in mind that later work might be directed towards exploring or amplifying such features as the survey revealed in the individual cases of particular materials. In accordance with this approach to the work a small but adequate number of tests were made on each of the three materials.

Four tests were made at 450 deg. Cent. on the 0·2 per cent carbon steel, three of these (from initial tensile stresses of 8·4, 7·2 and 6 tons per square inch) were of seven days stage period, and one (from 7·2 tons per square inch initial tensile stress) of one day stage period. Three tests were made on RR59 aluminium alloy at 150 deg. Cent., two (from 5 and 4 tons per square inch initial tensile stress) were of seven days stage period, and one (from 5 tons per square inch initial tensile stress) of one day stage period. On this same alloy at 200 deg. Cent., two tests (both from 3 tons per square inch initial tensile stress) were made of seven days stage period. In the case of the magnesium alloy three tests were made at 20 deg. Cent., two of which (from 3 and 1·35 tons per square inch initial tensile stresses) were of seven days stage period, and one (from 3 tons per square inch initial tensile stress) of one day stage period. At 50 deg. Cent. on this same alloy two tests of seven days stage period were made from respectively 2 and 1·5 tons per square inch initial tensile stress.

In general, each series of stages in a particular test was concluded when it appeared likely that further stages would not produce creep characteristics of a purely primary nature. In this initial investigation into this field of research, it was felt that simplicity and clarity of results would most likely be achieved if the investigation were limited to primary creep conditions, and not extended to conditions where accelerating creep arose. In all series of tests the load level was continually increased, and no unloading occurred. Any equations derived from the work are accordingly uniquely applicable to loading, and loaded conditions only.

RESULTS OF TESTS

The whole of the results of the tests made in the course of the investigation are given in Tables III to XVI, and in Figs. 2 to 15.

In Tables III to XVI axial and shear creep rates measured at 150 hours or at twenty hours, and the corresponding individual and integrated axial, shear and octahedral strains are given. In Figs. 2 to 15 the actual creep strain-time curves of axial and shear creep strain during the succession of stage tests are shown. The remainder of the tables and figures relate to the comparison of the test results with predictions of certain well-known "mechanical" theories of creep, and with analytically derived equations which it appeared possible to the authors might represent the basis of the behaviour of the materials in the tests.

DISCUSSION OF THE RESULTS OF TESTS

It has been stated in the introduction to this paper that in complex stress creep tests under simple loading conditions, all the materials concerned in the present investigation were well represented by equations of the general form :

$$C_{ij} = AF(J_2)S_{ij}\phi(t)$$

(the components of the equation being defined in the introduction). For a tension torsion system T, S, the corresponding unit axial and shear creep rate equations become

$$Ca = \tfrac{1}{3}AF(J_2)[T]\phi(t)$$

$$Cc = 2AF(J_2)[S]\phi(t).$$

In contemplating an analytical approach to the representation of the complex stress creep of these metallic alloys under general loading conditions, the above-mentioned equations may accordingly reasonably be taken as the starting point.

Three major possibilities appear to arise.

(1) The equations may be used directly in their present form.

(2) They may be used in their present form, but in effect as a "tool" in the service of an added theoretical proposition.

(3) The equations though retaining the

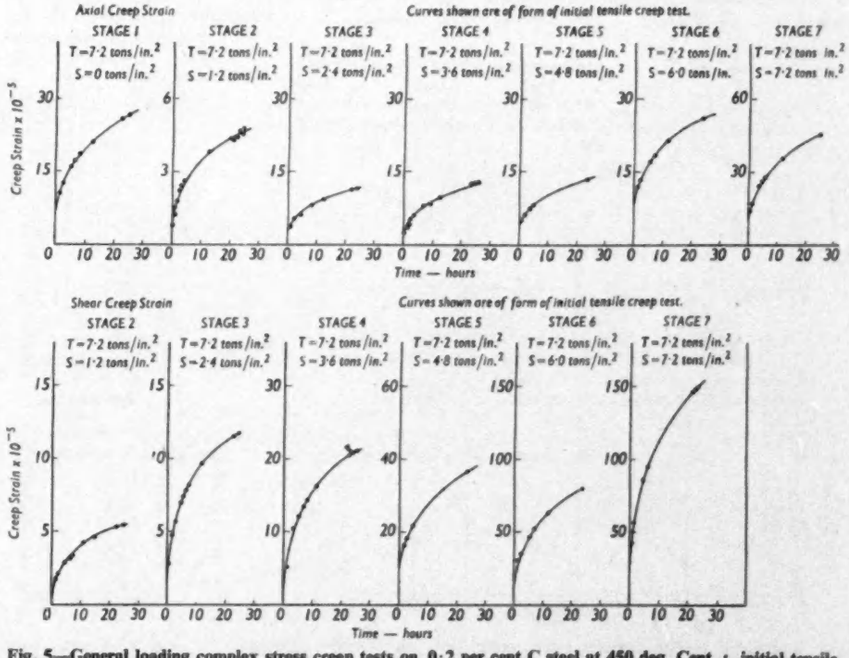


Fig. 5—General loading complex stress creep tests on 0·2 per cent C steel at 450 deg. Cent. : initial tensile stress 7·2 tons per square inch. Stage period 24 hours

basic elements of those cited above, undergo some modification in form to be applicable to a particular stage of a general loading test in virtue of their stress strain history corresponding to previous stages.

In what follows certain uses of the equations in accordance with the general possibilities outlined above are discussed, and at a later stage in the paper the support given to such ideas by the experimental data is examined.

In regard to the possibility (1), it has been pointed out by several authors that equations of this type are capable of yielding a number of solutions corresponding to rearrangements of the basic equation rendered possible by performing various mathematical processes of a simple nature.

In the Appendix an outline of these processes is given for the unit axial and shear creep rates and strains of the tension torsion system applied to these tests. Here it may simply be stated that apart from the current form, viz.,

$$(a) \quad C_{ij}=AF(J_2)S_{ij}\phi(t)$$

the equations may be rearranged to give forms

$$(b) \quad C_{ij}=\frac{F_1[AF(J_2)S_{ij}]}{f_1(\varepsilon_{ij})}$$

where ε_{ij} is the creep strain, and

$$(c) \quad C_{ij}=\frac{F_2[AF(J_2)S_{ij}]\phi(t)}{f_2(\varepsilon_{ij})}.$$

For the case of simple loading creep these equations are precisely equivalent, and give the same results. If, however, they be used to link the results of, say, complex stress creep tests with complex stress relaxation tests, they may be expected to give different predictions. Equally if applied to general loading complex stress creep data, they would again differently predict the course of creep from stage to stage of the tests.

The object of the present inquiry is to ascertain whether in regard to general loading complex stress creep tests on the current materials, any of the several types of equation noted gives a prediction in line with the experimental results. The three equations (*a*), (*b*), and (*c*), of course correspond to the three " mechanical " theories commonly termed, " Age Hardening," " Strain Hardening," and " Combined Age and Strain Hardening." The first of these theories simply expresses the idea that the creep rate is dependent only upon the current stress and the time at operating temperature whatever the path by which the stress is reached. The second in effect states that the creep rates depend only on the current stress and strain, however the stress be reached. The combined strain and time hardening theory indicates that creep rate is dependent upon stress and both creep strain and time however the stress be reached. On the basis of these equations the course of creep strain from stage to stage of a general loading test can be predicted as is indicated in the Appendix. Accordingly in the analysis of the results obtained the unit axial and shear creep strains are compared with corresponding strains predicted on the basis of an assumption of each of the above theories.

In regard to the possibility (2) that the basic equations might be used in an unaltered form, but in effect as a " tool " in the service of an added theoretical proposition, it is to be noted that in recent years one or two authors have advocated extension of the Boltzmann superposition theory which normally (and as originally stated by Boltzmann) simply applied to an elastic creep strain of unit stress dependence, to the case of permanent creep strain of (in general) more than unit stress dependence. The theory is well adaptable to the case where spontaneous changes in stress level are made during the strain history, as in the present general loading tests. The basic assumption of the superposition theory is that for each element of loading, a corresponding element of creep strain continues uninterrupted to the conclusion of all stages of the test, the total creep being the sum of all such elements. For example if a stress σ be added at time t, and if creep strain be proportional to powers of stress and time, then the creep strain due to σ which occurs is $\varepsilon=K\sigma^n\ (t_N-t)^M$ where t_N is the final time of reference.

If several operations involving the addition of elements of stress σ_1, σ_2, &c. occur then the total creep strain is

$$\Sigma\varepsilon=\left[\Sigma K\sigma_N{}^n(t_N-t)^M\right]_{t_N}^{0}.$$

In the Appendix the application of such processes to the estimation of axial and shear strains in the present tests is indicated.

Finally, there is the possibility that the form of the equations as suitable for use in

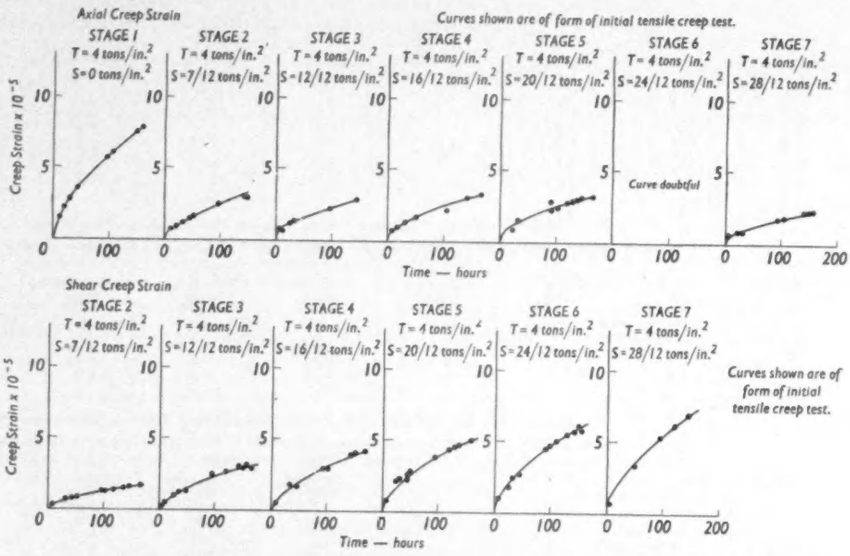

Axial Creep Strain
Curves shown are of form of initial tensile creep test.
STAGE 1 T = 4 tons/in.² S=0 tons/in.²
STAGE 2 T = 4 tons/in.² S=7/12 tons/in.²
STAGE 3 T = 4 tons/in.² S=12/12 tons/in.²
STAGE 4 T = 4 tons/in.² S=16/12 tons/in.²
STAGE 5 T = 4 tons/in.² S=20/12 tons/in.²
STAGE 6 T = 4 tons/in.² S=24/12 tons/in.²
STAGE 7 T = 4 tons/in.² S=28/12 tons/in.²
Curve doubtful
Creep Strain x 10⁻⁵
Time — hours
Shear Creep Strain
STAGE 2 T = 4 tons/in.² S=7/12 tons/in.²
STAGE 3 T = 4 tons/in.² S=12/12 tons/in.²
STAGE 4 T = 4 tons/in.² S=16/12 tons/in.²
STAGE 5 T = 4 tons/in.² S=20/12 tons/in.²
STAGE 6 T = 4 tons/in.² S=24/12 tons/in.²
STAGE 7 T = 4 tons/in.² S=28/12 tons/in.²
Curves shown are of form of initial tensile creep test.

Fig. 7—General loading complex stress creep tests on RR59 aluminium alloy at 150 deg. Cent. : initial tensile stress 4 tons per square inch ; stage period 167 hours

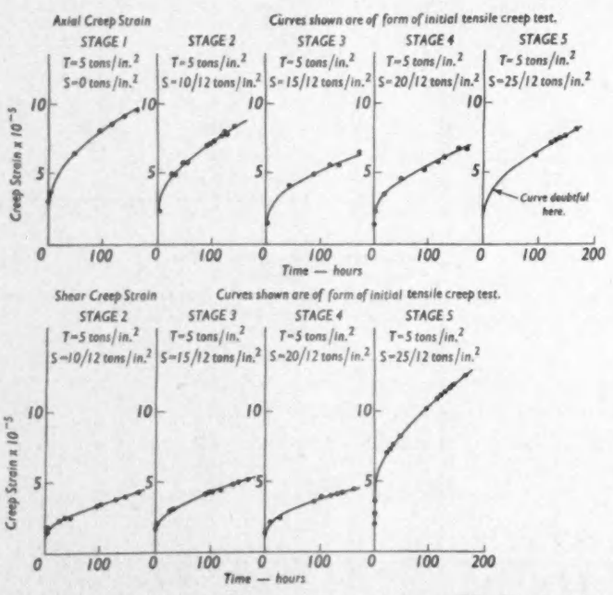

Axial Creep Strain
Curves shown are of form of initial tensile creep test.
STAGE 1 T=5 tons/in.² S=0 tons/in.²
STAGE 2 T=5 tons/in.² S=10/12 tons/in.²
STAGE 3 T=5 tons/in.² S=15/12 tons/in.²
STAGE 4 T=5 tons/in.² S=20/12 tons/in.²
STAGE 5 T=5 tons/in.² S=25/12 tons/in.²
Curve doubtful here.
Creep Strain x 10⁻⁵
Time — hours
Shear Creep Strain
Curves shown are of form of initial tensile creep test.
STAGE 2 T=5 tons/in.² S=10/12 tons/in.²
STAGE 3 T=5 tons/in.² S=15/12 tons/in.²
STAGE 4 T=5 tons/in.² S=20/12 tons/in.²
STAGE 5 T=5 tons/in.² S=25/12 tons/in.²

Fig. 6—General loading complex stress creep tests on RR 59 aluminium alloy at 150 deg. Cent. : initial tensile stress 5 tons per square inch ; stage period 167 hours

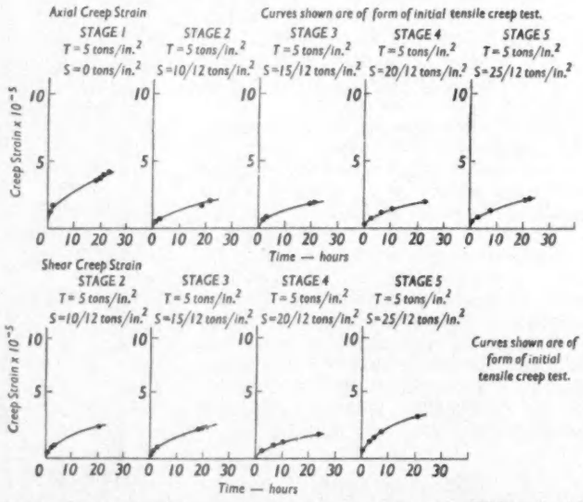

Axial Creep Strain
Curves shown are of form of initial tensile creep test.
STAGE 1 T = 5 tons/in.² S=0 tons/in.²
STAGE 2 T = 5 tons/in.² S=10/12 tons/in.²
STAGE 3 T = 5 tons/in.² S=15/12 tons/in.²
STAGE 4 T = 5 tons/in.² S=20/12 tons/in.²
STAGE 5 T = 5 tons/in.² S=25/12 tons/in.²
Creep Strain x 10⁻⁵
Time — hours
Shear Creep Strain
STAGE 2 T = 5 tons/in.² S=10/12 tons/in.²
STAGE 3 T = 5 tons/in.² S=15/12 tons/in.²
STAGE 4 T = 5 tons/in.² S=20/12 tons/in.²
STAGE 5 T = 5 tons/in.² S=25/12 tons/in.²
Curves shown are of form of initial tensile creep test.

Fig. 8—General loading complex stress creep tests on RR59 aluminium alloy at 150 deg. Cent. : initial tensile stress 5 tons per square inch ; stage period 24 hours

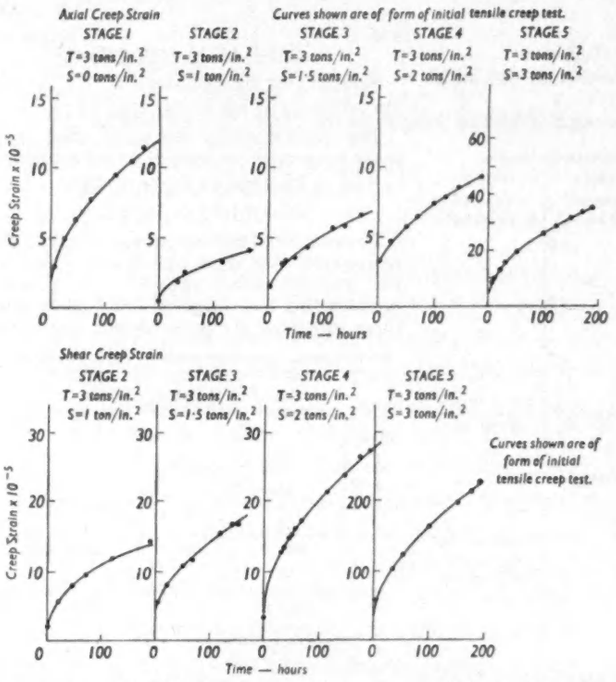

Axial Creep Strain
Curves shown are of form of initial tensile creep test.
STAGE 1 T=3 tons/in.² S=0 tons/in.²
STAGE 2 T=3 tons/in.² S=1 ton/in.²
STAGE 3 T=3 tons/in.² S=1·5 tons/in.²
STAGE 4 T=3 tons/in.² S=2 tons/in.²
STAGE 5 T=3 tons/in.² S=3 tons/in.²
Creep Strain x 10⁻⁵
Time — hours
Shear Creep Strain
STAGE 2 T=3 tons/in.² S=1 ton/in.²
STAGE 3 T=3 tons/in.² S=1·5 tons/in.²
STAGE 4 T=3 tons/in.² S=2 tons/in.²
STAGE 5 T=3 tons/in.² S=3 tons/in.²
Curves shown are of form of initial tensile creep test.

Fig. 9—General loading complex stress creep tests on RR59 aluminium alloy at 200 deg. Cent. : initial tensile stress 3 tons per square inch ; (first test) stage period 167 hours

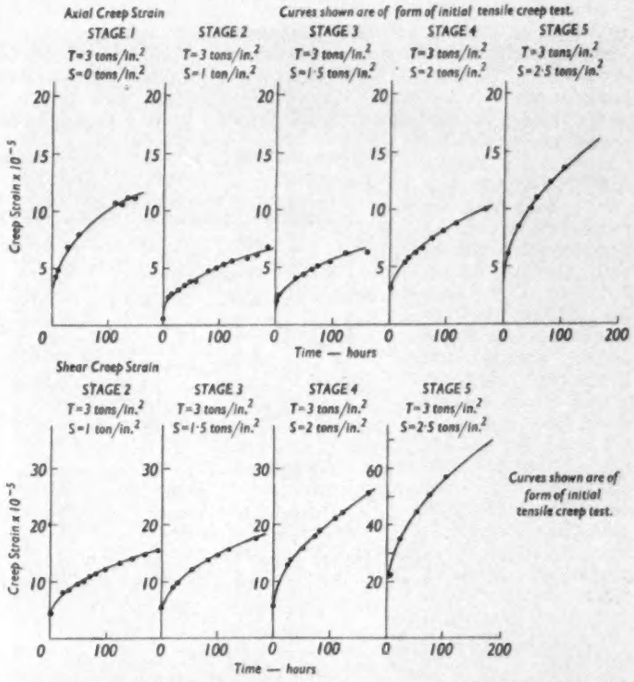

Axial Creep Strain
Curves shown are of form of initial tensile creep test.
STAGE 1 T=3 tons/in.² S=0 tons/in.²
STAGE 2 T=3 tons/in.² S=1 ton/in.²
STAGE 3 T=3 tons/in.² S=1·5 tons/in.²
STAGE 4 T=3 tons/in.² S=2 tons/in.²
STAGE 5 T=3 tons/in.² S=2·5 tons/in.²
Creep Strain x 10⁻⁵
Time — hours
Shear Creep Strain
STAGE 2 T=3 tons/in.² S=1 ton/in.²
STAGE 3 T=3 tons/in.² S=1·5 tons/in.²
STAGE 4 T=3 tons/in.² S=2 tons/in.²
STAGE 5 T=3 tons/in.² S=2·5 tons/in.²
Curves shown are of form of initial tensile creep test.

Fig. 10—General loading complex stress creep tests on RR59 aluminium alloy at 200 deg. Cent. : initial tensile stress 3 tons per square inch ; (second test) stage period 167 hours

general loading tests, although retaining the elements of the basic equations, undergoes some modification in form as applicable to a particular stage of a general loading test, in virtue of the stress strain history corresponding to previous stages. It should here be stated that in previous papers by one of the authors, it was noted that the form of equation

$$C_{ij}=AF(J_2)S_{ij}\phi(t)$$

expressing the results of simple loading creep tests was in fact a relatively simple variety of the Prager[2] general stress strain equations adapted to suit creep conditions.

These equations, intrinsically based upon the assumption that a series expansion of creep rate in terms of stress may be made, have the following general form for simple loading conditions :

$$C_{ij}=G_{(J_2,J_3)}\left\{p_{(J_2,J_3)}S_{ij}+q_{(J_2,J_3)}T_{ij}\right\}\phi(t)$$

where T_{ij} is the deviation of the square of the stress deviation,[3] $p_{(J_2,J_3)}$, and $q_{(J_2,J_3)}$ are simply stress functions in J_2, and J_3 (J_3 being the third stress invariant $=\frac{1}{3}(S_{ij}.\ S_{jk}.\ S_{ki})$, and G is a function which in the virgin state of the material simply depends upon the invarients of stress, but which is open to generalisation for other than virgin states. Obviously the possible application of more general varieties of the Prager equations to the condition of general loading is worth exploring.

The established simple loading equation $C_{ij}=AF(J_2)(S_{ij})\phi(t)$ in the terminology of the Prager equation becomes

$$C_{ij}=G(J_2)(S_{ij})\phi(t)$$

The most likely generalisation of this equation to general loading conditions would seem to be that the function G which is simply dependent on stress, i.e. $G=G_{(J_2)}$ for simple loading conditions, might depend in the more general conditions upon the strain history of the test piece. At this point it is perhaps worth while to emphasise the unique circumstances which condition the strain history of a test piece creeping under general loading conditions at high

[2] Ref. Prager, W., "Strain Hardening Under Combined Stresses." *Journal of Applied Physics*. Vol. 16, December, 1945.

[3] $T_{ij}=S_{ik}S_{kj}-\frac{1}{3}J_2\delta_{ij}$ where δ_{ij} is the Kronecka delta.

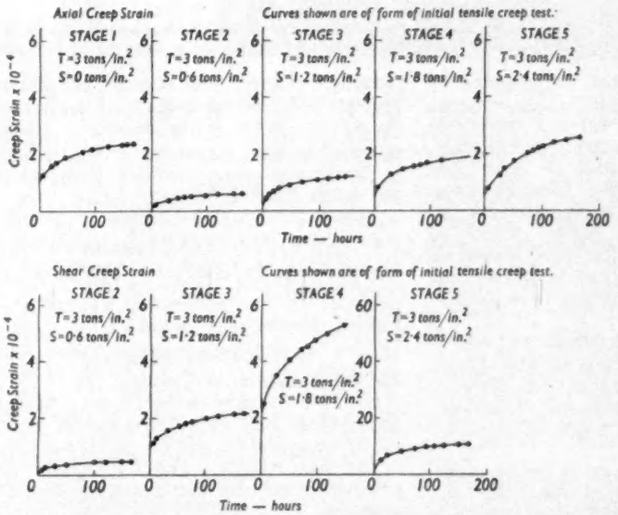

Axial Creep Strain
Curves shown are of form of initial tensile creep test.
STAGE 1 T=3 tons/in.² S=0 tons/in.²
STAGE 2 T=3 tons/in.² S=0·6 tons/in.²
STAGE 3 T=3 tons/in.² S=1·2 tons/in.²
STAGE 4 T=3 tons/in.² S=1·8 tons/in.²
STAGE 5 T=3 tons/in.² S=2·4 tons/in.²
Creep Strain x 10⁻⁴
Time — hours
Shear Creep Strain
STAGE 2 T=3 tons/in.² S=0·6 tons/in.²
STAGE 3 T=3 tons/in.² S=1·2 tons/in.²
STAGE 4 T=3 tons/in.² S=1·8 tons/in.²
STAGE 5 T=3 tons/in.² S=2·4 tons/in.²
Curves shown are of form of initial tensile creep test.

Fig. 11—General loading complex stress creep test on magnesium alloy at 20 deg. Cent. : initial tensile stress 3 tons per square inch ; stage period 167 hours

temperatures. Obviously the effects of any given degree of pre-strain in modifying the behaviour of the material under a newly imposed stress system is dependent in general on the period the material has been at temperature, and cannot necessarily be expected to remain the same throughout the strain history since, in general, some degree of thermal softening will occur in due course of time. Accordingly it is possible to imagine that the modification of one function G in the Prager equation by strain history, might be of three varieties

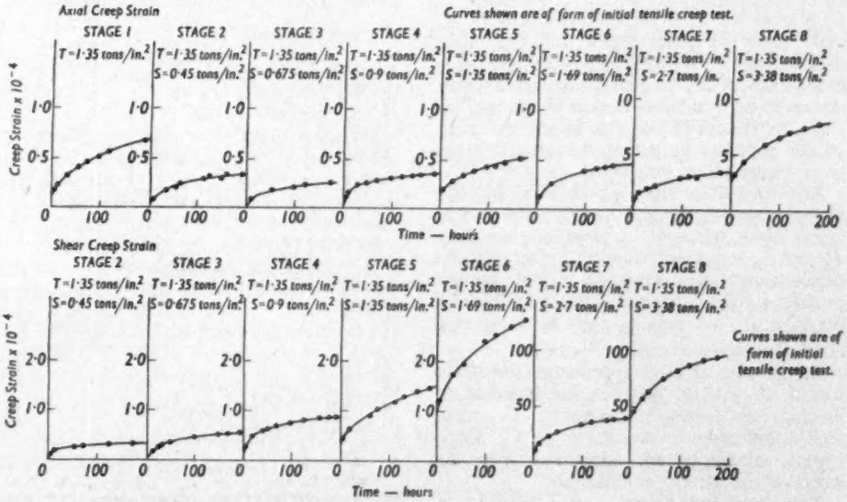

Axial Creep Strain
Curves shown are of form of initial tensile creep test.
STAGE 1 T=1·35 tons/in.²
STAGE 2 T=1·35 tons/in.² S=0·45 tons/in.²
STAGE 3 T=1·35 tons/in.² S=0·675 tons/in.²
STAGE 4 T=1·35 tons/in.² S=0·9 tons/in.²
STAGE 5 T=1·35 tons/in.² S=1·35 tons/in.²
STAGE 6 T=1·35 tons/in.² S=1·69 tons/in.²
STAGE 7 T=1·35 tons/in.² S=2·7 tons/in.
STAGE 8 T=1·35 tons/in.² S=3·38 tons/in.²
Creep Strain x 10⁻⁴
Time — hours
Shear Creep Strain
STAGE 2 T=1·35 tons/in.² S=0·45 tons/in.²
STAGE 3 T=1·35 tons/in.² S=0·675 tons/in.²
STAGE 4 T=1·35 tons/in.² S=0·9 tons/in.²
STAGE 5 T=1·35 tons/in.² S=1·35 tons/in.²
STAGE 6 T=1·35 tons/in.² S=1·69 tons/in.²
STAGE 7 T=1·35 tons/in.² S=2·7 tons/in.²
STAGE 8 T=1·35 tons/in.² S=3·38 tons/in.²
Curves shown are of form of initial tensile creep test.

Fig. 12—General loading complex stress creep tests on magnesium alloy at 20 deg. Cent. : initial tensile stress 1·35 tons per square inch ; stage period 170-200 hours

according as thermal softening is inappreciable in its effects, balances strain hardening, or finally overtakes any potential strain hardening.

The object of the present article is, of course, to examine the nature of the unique behaviour of the material arising from the generalisation of the complex stress system, with, however, the restriction that such examination be not extended to the effects of the generalisation of the stress system on the onset of tertiary creep and ultimately fracture. By suitable selection of test temperatures it was hoped to obtain some indication of the modification produced in G under circumstances where prestrain fulfills its general function of reducing creep rate, and also possibly where such reduction was trivial. The third case mentioned in previous paragraphs in which definite softening and presumably increase of creep rates above those which would be predicted by the virgin material simple loading complex stress creep equations was not considered to be part of the present investigation. In this connection it must be emphasised that the simple loading complex stress equations used were quite definitely restricted in validity to limited periods of time, and accordingly the total length of any general loading test had to be restricted to lengths of time reasonably in the neighbourhood of these.

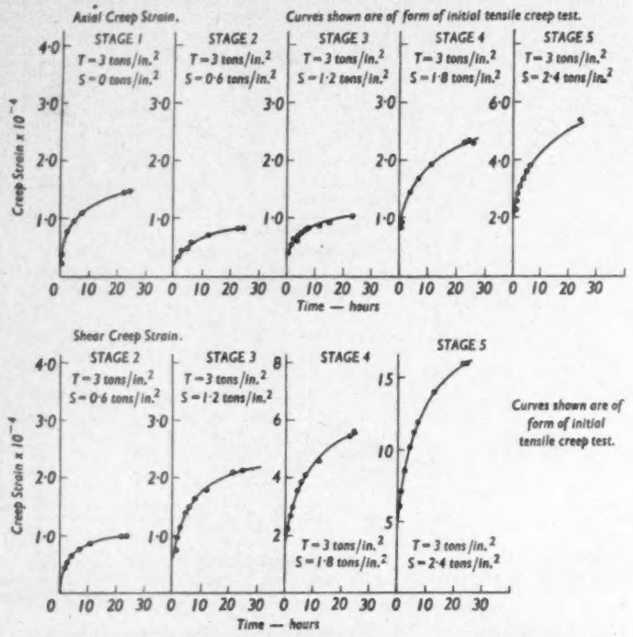

Axial Creep Strain.
Curves shown are of form of initial tensile creep test.
STAGE 1
T = 3 tons/in.²
S = 0 tons/in.²
STAGE 2
T = 3 tons/in.²
S = 0·6 tons/in.²
STAGE 3
T = 3 tons/in.²
S = 1·2 tons/in.²
STAGE 4
T = 3 tons/in.²
S = 1·8 tons/in.²
STAGE 5
T = 3 tons/in.²
S = 2·4 tons/in.²
Creep Strain x 10⁻⁴
Time — hours
Shear Creep Strain.
Curves shown are of form of initial tensile creep test.

Fig. 13—General loading complex stress creep tests on magnesium alloy at 20 deg. Cent. : initial tensile stress 3 tons per square inch ; stage period 24 hours

In what follows, an approach is outlined to the problem of framing suitable Prager type equations to represent the effect of strain history on the function G. In general, such strain dependence might be expressed in two possible manners.

(*a*) Generally, by means of the invariants I_2, I_3, of integrated creep strain (or presumably creep plus plastic strain where this latter occurs), taking place previous to the current stage of the test. This is precisely equivalent in nature to the dependence of G in terms of stress on the invariants J_2, J_3, and simply in effect states that the effect of strain history on the creep rate is generally a function of all principal integrated creep strains in each successive stage of the test.

(*b*) By means of the unit integrated creep strains previous to test in the specific plane of reference i.e. ε_{ij} integrated.

In case (*a*) in view of the fact that the virgin material showed a relatively simple stress dependence on J_2, and not on both J_2, and J_3, it may initially be hoped that the dependence upon prestrain might be expressed simply in terms of the second strain invariant I_2, or equally well by integrated octahedral creep strain $\varepsilon_0=\sqrt{2}/\sqrt{3}\sqrt{I_2}$.

In the case of both approaches the strain would on general grounds be expected to produce an increased resistance to creep, and a lowering of the value of C_{ij} for a specific stress system compared with the same system for virgin material.

Thus the simple forms

(*a*) $G=[AF(J_2)-f(I_2)]$

or

(*b*) $G=[AF(J_2)-f(\varepsilon_{ij})]$

do not appear unreasonable as an initial possibility.

Since hardening of the material leading to reduction of creep rate is likely on general grounds to be related to the work performed during the course of the respective strains, it would not be surprising to find $\sqrt{I_2}$ or ε_{ij} involved as power functions of exponent nor widely differing from unity.

Corresponding to the equation

(*c*) $C_{ij}=[AF(J_2)-f(I_2)]S_{ij}\phi(t)$

the equations for the unit creep rates are

$$Cx=\tfrac{1}{2}[AF(J_2)-f(I_2)][(\sigma_x-\sigma_y)-(\sigma_z-\sigma_x)]\phi(t)$$

and two similar terms Cy and Cz

$$Cxy=2[AF(J_2)-f(I_2)][\tau_{xy}]\phi(t)$$

and two similar terms Cyz and Czx.

For the tension-torsion stress systems employed in the current experimental work, viz. $\sigma_x=T$, $\sigma_y=\sigma_z=0$, and $\tau_{xy}=S$, $\tau_{yz}=\tau_{zx}=0$.

The unit rates Cx and Cy become the measured axial rate Ca, and shear rate Cc given by

$$Ca=\tfrac{2}{3}\{AF(J_2)-f(I_2)\}[T]\phi(t)$$

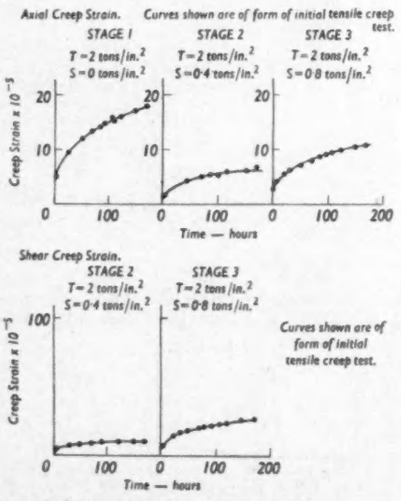

Axial Creep Strain.
Curves shown are of form of initial tensile creep test.
STAGE 1
T = 2 tons/in.²
S = 0 tons/in.²
STAGE 2
T = 2 tons/in.²
S = 0·4 tons/in.²
STAGE 3
T = 2 tons/in.²
S = 0·8 tons/in.²
Creep Strain x 10⁻⁵
Time — hours
Shear Creep Strain.
Curves shown are of form of initial tensile creep test.

Fig. 14—General loading complex stress creep tests on magnesium alloy at 50 deg. Cent. : initial tensile stress 2 tons per square inch ; stage period 167 hours

and

$$Cc=2\{AF(J_2)-f(I_2)\}[S]\phi(t).$$

Similarly for the equation

(*d*) $C_{ij}=[AF(J_2)-f(\varepsilon_{ij})][S_{ij}]\phi(t)$.

The experimentally measured axial, and shear creep rates correspond to the equations

$$Ca=\tfrac{2}{3}[AF(J_2)-f(\varepsilon_a)][T]\phi(t)$$

$$Cc=2[AF(J_2)-f(\varepsilon_c)][S]\phi(t).$$

It is to be noted that equations of the type (*d*). correspond with some change of volume of the material since $\Sigma C_{ij}\neq 0$. On general grounds this fact suggests immediately that these equations are probably the less likely

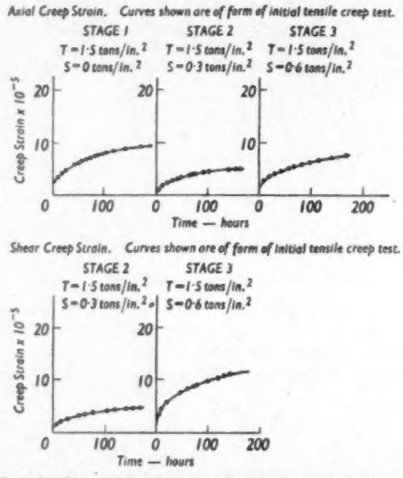

Axial Creep Strain. Curves shown are of form of initial tensile creep test.
STAGE 1
T = 1·5 tons/in.²
S = 0 tons/in.²
STAGE 2
T = 1·5 tons/in.²
S = 0·3 tons/in.²
STAGE 3
T = 1·5 tons/in.²
S = 0·6 tons/in.²
Creep Strain x 10⁻⁵
Time — hours
Shear Creep Strain. Curves shown are of form of initial tensile creep test.

Fig. 15—General loading complex stress creep tests on magnesium alloy at 50 deg. Cent. : initial tensile stress 1·5 tons per square inch ; stage period 167 hours

of the two types to represent the results, since where information has been available, it appears to indicate that quite considerable creep strain can occur without appreciable change of density.

Having determined the form of $F(J_2)$ from the family of tests available, in all cases for the virgin material, the axial and shear creep rates are determined for each current stress system at a particular stage of the general loading test, making use of the equation for virgin material.

$$C_{ij}=[AF(J_2)][S_{ij}]\phi(t).$$

The ratio

$$\frac{Ca\text{ (experimental)}}{Ca\text{ (on the basis of virgin material equation)}}$$

and

$$\frac{Cc\text{ (experimental)}}{Cc\text{ (on the basis of virgin material equation)}}$$

are then derived for all stages of the test.

Suppose either of the above ratios has the value K, so that for the actual experimental material at this stage, in effect

$$C_{ij}=K[AF(J_2)][S_{ij}]\phi(t)=[A'F(J_2)][S_{ij}]\phi(t).$$

Then

$$K=A'/A.$$

Now, since for the modified material

$$C_{ij}\text{ really}=\begin{bmatrix}AF(J_2)-f(I_2)\\ \text{or } -f(\varepsilon_{ij})\end{bmatrix}[S_{ij}]\phi(t)$$

we have $f(I_2)$ or $f(\varepsilon_{ij})$ has the numerica value of $[A-A']\ F(J_2)=A[1-K]F(J_2)$, whence for particular stages of all general loading tests values of $f(I_2)$ and $f(\varepsilon_{ij})$ corresponding to axial and shear strains can be estimated and plotted against the integrated values of the quantities ε_0 or $\sqrt{I_2}$ and ε_{ij}.

In such plots, if either of the above equations represent the behaviour of the material, the values of $f(I_2)$ or $f(\varepsilon_{ij})$ for both axial and shear strain, and for all stresses should be upon a single continuous curve.

(To be continued)

Queen Elizabeth Dock, Falmouth

A dry dock large enough to accommodate tankers of 85,000 tons has been constructed at Falmouth, and is shown at an advanced stage of construction on the right. It has been virtually cut from solid rock, its length being 850ft, and its width at the entrance 130ft. The comprehensive services nowadays provided at a ship-repairing dock have been installed, but in addition there is one innovation. Bilge blocks can be traversed and elevated by hydraulic machinery, according to a setting-out which will suit the next ship to be docked. There are thirty-six of these blocks installed in the dock floor, each of which will take a load of 1000 tons ; they can be positioned while the dock is "wet." The work includes a large underground pumping station.

THE Queen Elizabeth dry dock at Falmouth is due to come into service this month. The dock is a large one, capable of docking tankers up to 85,000 tons deadweight. Its principal dimensions are listed in the table, and it is shown nearly completed in the accompanying illustration. The dock is owned by the Falmouth Dock and Engineering Company, Ltd., and Silley, Cox and Co., Ltd., and these firms carried out its design and construction.

The dock has been excavated from solid rock ; a high cliff had first to be excavated, and then the dock itself. The rock spoil was used for reclamation on the dock estate. These site conditions contrast strongly with the problems generally associated with dry dock construction, involving water-bearing ground, and very poor soil materials.

The dock is well-serviced for carrying out repair work. Ancillary work has included the construction of an underground pumping station which controls the new dock, and three existing ones besides. However, the feature which will probably attract greatest interest is the installation of traversing bilge blocks. The size of the dock is such that small ships—that is below the range of 65,000 tons deadweight which is best suited to the dock—could not be supported by the usual timber shores. Hydraulically-controlled bilge blocks set in the floor of the dock can thus be traversed and elevated to suit the shape of the particular ship which is to be docked.

This operation of setting the bilge blocks hydraulically is carried out from a control station on the altar. It can be done while one vessel is leaving and another entering the dock on the same tide, without dewatering the dock.

The blocks can be traversed under water for a distance of 25ft by operating a hand-wheel in the control station. The position of the block from the centre line of the dock can be read on an indicator on the control panel. Vertical movement of the block is obtained pneumo-hydraulically by a valve on the control panel. Zero and contact positions with the ship's hull are indicated on the panel by a green and red light, respectively, and a height indicator graduated in eighths of an inch over a range of 9in shows the elevation. There are thirty-six blocks, eighteen on each side of the dock, spaced approximately 33ft apart. The spacing and numbers are designed to cover the extent of the "flat" of the bottom of the largest vessels to dock, but they can also accommodate two smaller ships in line ahead. The area of timber on the top of the bilge block has been chosen to give adequate support to the vessels' outer bottom plating panels, and the traversing distance scheduled for each ship will ensure supporting the ship under a main longitudinal bulkhead or girder.

Each block is designed for a load of 1000 tons. Together with their control arrangements, they were designed by the owners, using equipment supplied by the Climax Rock Drill Engineering Company, Ltd., and Holman Brothers, Ltd.

Cast iron keel blocks 4ft 9in high are fitted on the centre line of the dock over the full length of the dock floor. They are spaced 2ft 6in apart, centre to centre, except at the entrance and the head where, for a considerable distance, they are not only very closely spaced but are tied to the dock floor in pier formations. This precaution has been taken to resist the severe loading conditions imposed on keel blocks when a ship is docked with trim, i.e. she is either drawing more water aft than forward, or vice versa.

A total of 370 keel blocks is installed and each one weighs 2½ tons. A keel block is composed of three separate cast iron pieces, the centre piece being a wedge having a taper which is self-locking under compression. Best quality English oak has been used for the top timber.

The accompanying table also lists the installation of pumps in the pumping station. The dock can be flooded in one hour by opening two 8ft diameter power-operated equilibrium valves. The three main pumps can dewater the dock in less than three hours.

The dock gate—it is hinged at sill level according to the now well-known "Box" design—is considered to be the largest of its kind. It is 134ft wide by 40ft 3in high by 9ft 6in thick. It has rubber seals, and is operated by an 85 h.p. electric winch with automatic slack rope control which is situated in the pumping station. The gate is controlled from a button on the altar, which actuates the winch. The gate was supplied by Sir William Arrol and Co., Ltd.

The principal dock cranes are a travelling crane of 48 tons capacity and two 10-ton cranes.

Other services installed at the dock include six electric capstans each capable of giving a 16-ton pull. In the service culverts there are mains for fresh water, ballast water, steam, compressed air, oxygen, acetylene, a.c. and d.c. electricity, and telephones. The culvert opens out into service bays at every 100ft, directly accessible to the single altar which is 8ft below the coping.

Principal Dimensions of the Queen Elizabeth Dock

Length, ft	850
Width between side walls, ft	136
Width at entrance, ft	130
Depth over sill at H.W.O.S.T., ft	36
Depth over sill at L.W.O.S.T., ft	20

Materials in construction

Rock excavation from cliff, cubic yards	250,000
Rock excavation from graving dock, cubic yards	300,000
Concrete, cubic yards	70,000
Steel reinforcement (approximately), tons	650
Steel piling in cofferdam, tons	610
Steel in "Box" gate, tons	500

Pump house plant

Pumps	No.	Size, in	B.h.p. motor	Gallons per minute	Tons per hour	Head, ft
Main	3	48	650	53,500	14,500	28
Drainer	2	20	160	7,500	2,000	50
Ballast	1	20	480	7,500	2,000	150
Fire	1	12	230	1,875	500	270
Cooling water for air compressors	1	5	17½	320	86	100
Pump house drainage	1	2½	2½	75	20	40

LETTERS AND LITERATURE

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

"THE SPIRIT OF ENGINEERING"

SIR,—Mr. Clausen has made a notable contribution to the subject of engineering culture, in his lecture to the Institution of Engineering Designers, as reported in your issue of June 20, 1958.

It will readily be agreed that engineering is an important part of the foundations of our prosperity, our safety and our cultural development, and I agree with the lecturer's remarks on the need for a better integration of the various aspects of engineering knowledge to ensure the steady development of our civilisation in an orderly way. This integration is a responsibility of engineers all over the world, as it is independent of any false limitations arising from national introspection or geographical boundaries.

How do we, as engineers, set about putting our house in order? It is often easier to uncover our errors than it is to propose a remedy—the object of my letter, is however, to suggest a few ideas for consideration.

During recent years it is noted, with regret, that scientific knowledge is being subordinated to a political control, it has lost some of its international freedom, the same is also true of engineering knowledge, the difference being that the economist, the accountant, the secretariat, the financial interests, have taken charge of the growth and distribution of engineering knowledge. This may be the cause of the widespread lack of interest in the cultural development of engineering. Engineers are not adequately represented at the top, i.e. on the seats of learning and boards of management.

Mr. Clausen has put his finger on some of the weaknesses and has pointed out some ways of remedying the bad effects. What I think he may be seeking to establish is an appreciation or awareness in the minds of all intellectual men and women of the "spirit of engineering," as distinct from the "mechanics of engineering," an intelligent awareness of that dynamic inspiration which is the source of all progressive activity. In a greater or lesser degree, the functions of engineering cover nearly all the activities of man. Mr. Clausen's lecture will have started a chain of thoughts in many people's minds concerning the possibility of uncovering some basic root-notions which are already embodied in the culture of engineering knowledge, which would form the seed-plot in which engineering culture would grow. Most of the arts and some of the sciences and many of the religions of the world have such a seed plot, out of which all subsequent development has grown.

Take music. The seven notes, operating within a four-dimensional calculus of tone, rhythm, melody, harmony, is the basis of all music; it is the government and system of all musical composition.

Take mathematics. The ten digits operating within a four-dimensional calculus of addition, subtraction, multiplication, division, is the basis and principle upon which all subsequent calculations are based; it is the rock upon which all culture in mathematics rests.

Take painting. The seven colours of the rainbow operating within a four-dimensional calculus of revelation, translation, reflection of the revelation, subjective interpretation of the revelation, is the foundation of all works of art and artistic culture.

Take religion. The symbolism of the Days of Creation outlined in Genesis, Chapter I, and the first three verses of Chapter II, operating in a calculus of Revelation, Translation, Christianity and scientific being, is the basis of all the subsequent Bible stories and of our understanding of evolution and Christian civilization.

Now what does all this mean to engineering culture? Why have not engineers sought for, found, and then applied a comparable range of root notions to the development of engineering science, the culture of engineering, or the "spirit of engineering" which Mr. Clausen has defined, if rather narrowly, as the philosophy of craftsmanship?

Could not this term "the spirit of engineering" be summarised as the "practice of bringing ideas to fulfilment"—just think for a moment; there are very few ideas being brought to fulfilment at this very moment of time which do not involve a whole lot of engineering culture.

Mr. Clausen has gone so far by providing a part of what seems to me to be required; he has described and named the four-dimensional calculus of engineering culture, i.e. "the science," "the art," "the industry," "the finance or commerce." It will be noted that there is common ground between the four categories in Mr. Clausen's statement, and the four-dimensional calculus through which all the other arts and sciences operate, the common ground will be seen if the following four simple words were substituted in each case: i.e. seeking, finding, using, being. It's the processes we all use in bringing ideas to fulfilment and engineering culture is stultified if it fails in its balance of these terms.

The science—i.e. the seeking.

The art—i.e. the finding of the way in practice.

The industry—i.e. the using of what has been found.

The finance or commerce—i.e. the understanding of the controlling principle upon which all development and all achievement is based.

This is obviously not the place to develop the details of this consideration, however: here are some suggestions:

(*a*) That engineers of good will, all over the world, should devote some time to think about this subject.

(*b*) Arising from (*a*), the profession should put forward ideas to bring engineering culture in line with the other basic arts.

(*c*) Engineers having found and dealt with the present defects in our thinking and actions may wish to approach the educational authorities with a view to establishing a basis for a better appreciation of the cultural activities of the engineering profession so that students coming into the orbit of engineering for training may be presented with a higher concept of the activities, aims and purpose of its contribution to human welfare and development.

Two points, in conclusion:

(i) I agree with your editorial comment, "there is no cause for depression." The British engineer has a fine understanding of the word quality and it comes before his understanding of the word quantity.

(ii) Referring to your editorial remarks in the same issue on "Women as Engineers," may I suggest that the womanly qualities of patience, endurance, care, persistence, are needed and should be welcomed by all in our profession.

Thank you, Mr. Clausen, for your fine analysis.

Sir Charles Parsons once said: "We are too apt to look on scientific progress as purely utilitarian. We forget that we merely harness the mechanisms of creation. We create nothing."

CHARLES OSBORNE

Torquay,
June 30, 1958.

RAILWAYS INTO ROADWAYS

SIR,—Mr. Dennis Gill's letter of June 26, brings a refreshing breath of common sense which should help to dispel some of the fantastic notions of the Railway Conversionists. The photograph of congested traffic at the Delaware River Bridge brings vividly to mind a recent experience in which it took three hours to travel 3 miles in a queue crossing the bridge over the River Dee at Queensferry, and of waiting half the day to cross the Firth of Forth by the car ferry.

To increase our dependence on imported liquid fuel is sheer folly. In this direction the decision to abandon steam locomotives and substitute oil engine hauled trains is as unwise as it is costly, albeit the step is only an interim measure pending the completion of electrification of the railways. Sir Claude Gibb's paper on "Nuclear Energy for Electricity Supplies" (*vide* THE ENGINEER, July 4) clearly shows that the world reserves of coal and oil will be quite incapable of meeting alone the demands for fuel if electricity consumption continues to increase as it has done in the past fifty years. As Sir Claude Gibb says, in burning coal and oil we are using up capital. It does not seem to be realised that we are heading for a tremendous decrease in the speed of travel on the roads. When coal is only mined as a source of chemicals and is too valuable for use as fuel, and when the rapidly diminishing reserves of oil are husbanded for the same reason, we shall have to depend on nuclear fuel to generate electricity and on alcohol to drive internal combustion engines. The use of such engines will be restricted to essential services such as tractors for use in agriculture and in aircraft, and for metallurgical and other

furnaces which must be fired with liquid fuel.

It cannot be supposed that enormous areas of land could be devoted to the cultivation of vegetable products from which alcohol could be made on a scale sufficient to replace even the present consumption of liquid fuel. When this time comes—as come it will—electric storage batteries will be the only source of power for the vast majority of vehicles which will then indeed be motor driven. And the limitations on speed and range of action are such that there will be unprecedent restrictions on the movement of traffic. Unless an altogether revolutionary change in the storage battery is brought about before the inevitable restrictions on the use of liquid fuel are forced on us traffic will be driven back to the railways, which will then be of inestimable value. Only the railways can make use of electricity generated from nuclear fuel—the only fuel which will then be available.

It is indeed high time to found an "Anti-Railway-Conversion League." Is Mr. Gill in earnest when he says that he is willing to help found such a body ?

E. B. PARKER

Llanferres,
Flintshire,
July 31, 1958.

Book Reviews

Transistor A.F. Amplifiers. By D. D. JONES, M.Sc., D.I.C. and R. A. HILBOURNE, B.Sc. Iliffe and Sons, Ltd., Dorset House, Stamford Street, London, S.E.1. Price 21s.

AT first sight it is surprising that a complete book should be devoted to such a specialised topic in a rather specialised field. The title is perhaps a trifle modest as some of the subject matter has applications outside the realm of pure audio frequency amplifier design, and with a thorough knowledge of the principles and practice contained in this book, a circuit engineer is well equipped to venture into other fields. The approach is one in which the minimum of algebra is employed and full use is made of the many valid approximations which occur in transistor circuit design. Such designs are shown not to be the fearsome things that the novice may suppose, but a logical and straightforward process.

The book is not suitable for anyone coming completely fresh to the subject ; the introductory chapter starts by explaining transistor action, but does it so briefly as to be of doubtful value. The treatment during the first few chapters is rather uneven in the standard of its technical content, but the major part of the book contains a well-balanced treatment of the subject. The sins of omission and commission are small and the book is well printed and laid out. One might have hoped for a pre-amplifier design using transformer coupled stages, for although *RC* coupled stages are generally to be preferred, there are cases when the former arrangement has advantages. For example—the use of transformers can sometimes result in a required amount of gain with fewer transistors. The way in which numerical values are assigned to the components r_e and r_b in the T-equivalent network does not meet with universal acceptance, but the practical consequences of this are not likely to be serious.

Transistor audio amplifier design is far from being a static art and there is a danger that a book of this sort will soon become out of date. While there will be a need for revision from time to time, most of the book is not ephemeral and the authors are to be commended on producing a work which is a positive contribution to their subject.

Schwingungsabwehr VDI–Berichte, Vol. 24, 1957. Düsseldorf. VDI–Verlag G.m.b.H., Düsseldorf 10, Postfach. Price DM.28.80 (for VDI members and subscribers DM. 25.90).

VDI REPORT Volume 24 contains the edited versions of twenty-one lectures and five contributions to the discussion of the Anti-Vibration Congress held in Essen on November 15 and 16, 1956. In his opening speech before the meeting, which was attended by 500 people, Professor Dr.-Phil. E. Lübcke, Berlin, outlined the organisation of vibration research within the Verein Deutscher Ingenieure.

The lectures which have now been collected in the present publication deal with many aspects of mechanical vibrations, such as problems in connection with elastically mounted rotors, gas turbine and compressor blades, magnetically excited vibrations in d.c. generators, model tests on brush holders of commutator machines, vibrations of the housings of electrical machinery, turbines and their foundations, measurements in buildings, weirs, optical and precision instruments, forge hammers, resonance-free piston engines, German Federal Railway's work on vibrations, flexural vibrations of different order, physiological effects of low frequency vibrations, the basis of noise abatement, silencing of car and motor-cycle engines, ventilators and jet engines, the problems arising from installing machine tools on upper floors of buildings.

A Guide for Industry to the Clean Air Act, 1956. Federation of British Industries, 21, Tothill Street, London, S.W.1. Price 4s.

THIS handbook on the provisions of the Clean Air Act which came into full operation on June 1 brings up to date the Federation's previous publication on this subject and includes the regulations which the Minister was empowered to make under the Act. It is intended as a working manual for the information of works managers and engineers, and therefore excludes reference to those provisions of the Act which concern only dwellings. The booklet is divided into three parts ; the first, on how to combat smoke, the second, on how to combat grit and dust, and a third miscellaneous section. Its various appendices include sections on the use of the Ringelmann Chart ; smoke density indicators ; description of dust-arresting equipment ; relevant British Standards ; a list of relevant Statutory Instruments ; and the names of manufacturers of the various kinds of equipment generally required.

Construction of Graphs and Charts. By Professor A. S. Hall. Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, Kingsway, London, W.C.2. Price 25s.

UNDERGRADUATE students are primarily catered for in this volume. The basic tenet is that the many advantages of graphical presentation of data and solutions of problems are not fully achieved unless the right kind of graph is chosen. The book is thus an introduction to the "technology of graphs." Its subject matter is grouped under the headings of Cartesian co-ordinates, polar co-ordinates, change of variable, graphical differentiation and integration, intercept charts, and nomograms. The last subject is not treated exhaustively.

Books of Reference

Hydraulic Handbook. Trade and Technical Press, Ltd., 1–9, Tudor Drive, Morden, Surrey. Price 90s.—This volume, stated to be the first handbook of its kind devoted to the subject of industrial hydraulics, has been compiled by the editors of *Hydraulic Power Transmission.* Its first main section includes comprehensive notes on the principles of hydraulics. These notes are followed by a survey of hydraulic equipment which includes detailed particulars of the construction and operation of accumulators, actuators, cylinders and rams, motors, pumps, seals, pipes, valves, fluids, controls, &c., with particulars of a number of interesting proprietary designs. Supplementing this part of the book are notes on the many and varied applications of hydraulic equipment in all branches of industry.

A section of the book giving technical data contains a considerable amount of information on hydraulic circuits, tables and charts and symbols and formulae which designers and draughtsmen concerned with hydraulic equipment will find very helpful in their work. The information given in this handbook is presented in a clear concise way and is well supplemented with clear illustrations, drawings and diagrams. This book will undoubtedly prove a very useful addition to the technical reference libraries of all firms concerned with the application and design of hydraulic industrial equipment.

Ship and Boat Builder Annual Review, 1958. John Trundell (Publishers), Ltd., St. Richard's House, Eversholt Street, London, N.W.1. Price 50s.—The review opens with a foreword by R. K. Anderson, the President Elect of the Ship and Boat Builders' National Federation, followed by a survey of Shipbuilding in Denmark and Italy and articles dealing with such diverse subjects as : the effects of gearing, American boat building, craftsmen and craftsmanship, air conditioning, improvement of fishing boats and small craft in Japan. There is a pictorial review of craft constructed in 1957 and a table of launches for the same year. A directory gives lists of builders at home and abroad, including facilities at the British yards, and this is followed by specifications of engines manufactured by the leading manufacturers. In the next section are given the specifications of paints as supplied by individual manufacturers and then there is a directory of marine fittings linked with names of makers, the addresses of whom are listed in another index. Data concerning different woods are recorded and also the suppliers of various materials, while another directory deals with yard equipment. Finally there are lists of consultants, associations, fleet owners, harbour authorities, yacht clubs and commercial diplomatic officers. A welcome innovation this year is the introduction of guide cards which make for easy reference to the various directories.

Books Received

Electrical Who's Who, 1958–59. Electrical Review Publications, Ltd., Dorset House, Stamford Street, London, S.E.1. Price 27s. 6d.

Colliery Year Book and Coal Trades Directory, 1958. Iliffe and Sons, Ltd., Dorset House, Stamford Street, London, S.E.1. Price 40s.

Acoustics, Noise and Buildings. By P. H. Parkin and H. R. Humphreys. Faber and Faber, Ltd., 24, Russell Square, London, W.C.1. Price 70s.

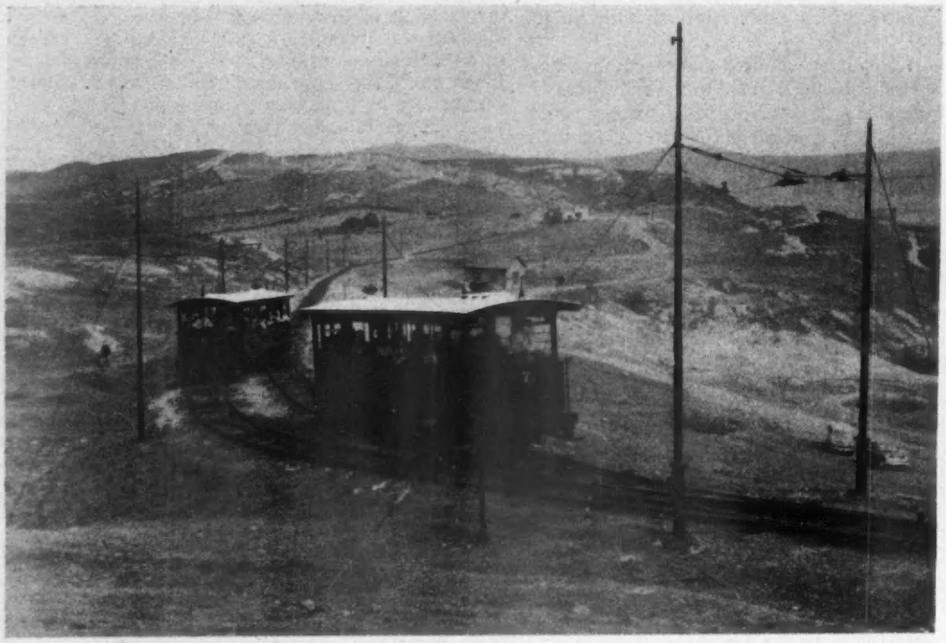
Glass-Melting Tank Furnaces. By Rudolf Gunther. Society of Glass Technology, Thornton, Hallam Gate Road, Sheffield, 10. Price 60s.

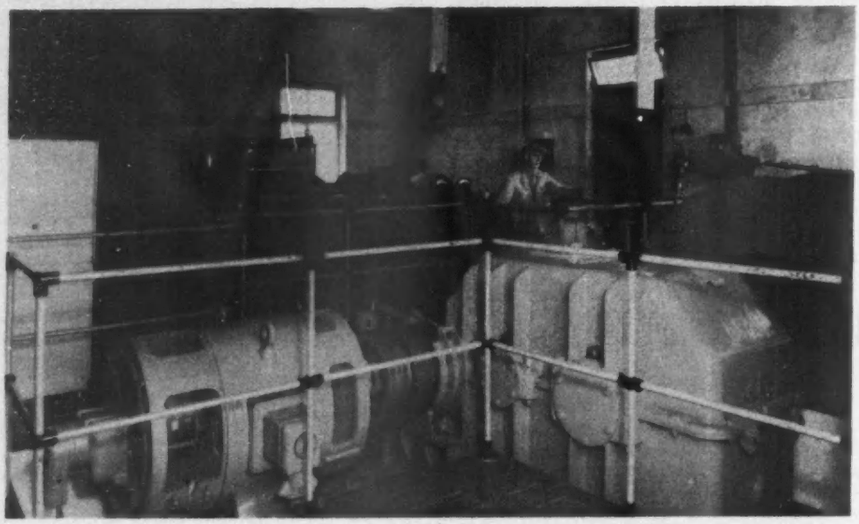
An Introduction to the Theory and Practice of Semiconductors. By A. A. Shepherd. Constable and Co., Ltd., 10, Orange Street, London, W.C.2. Price 18s.6d.

Engineering Drawing and Drawing Office Practice. Second edition. By P. S. Houghton. Crosby Lockwood and Son, Ltd., 26, Old Brompton Road, London, S.W.7. Price 20s.

Great Orme Railway

The electrical drive for a new winding gear on the Great Orme Railway at Llandudno has recently been installed by the English Electric Company, Ltd., to replace the steam engine drives originally installed when the railway was opened in 1902/3. It is a rope-hauled tramway, 3ft 6in gauge (ILLUSTRATED RIGHT), from Victoria Station to the summit of Great Orme, in two separate haulages. The lower haulage, 600 yards long with sharp curves, rises 400ft (maximum gradient 1 in 4·4); at a half-way station passengers change cars for the second haulage which is 827 yards long and rises 150ft (maximum gradient 1 in 10·3). On each haulage, two cars are connected by cables to their drums, so that one car ascends whilst the other descends. The cars on the upper haulage are also linked by a third cable passing round an idle pulley at the summit terminus.



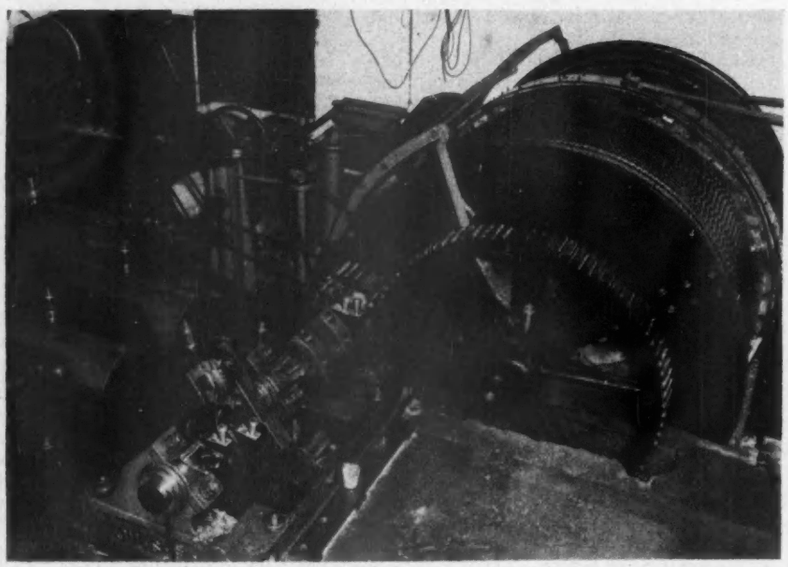


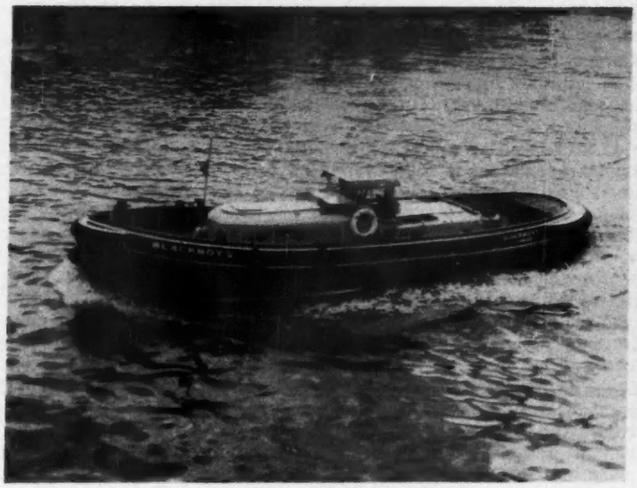
The half-way station houses the winding gear. The old drive and chain-driven governor are illustrated BELOW. The new drive consists of a 125 h.p. slipring induction motor, 730 r.p.m., for the lower haulage, and a similar 75 h.p. motor for the upper, each with rotor-resistance speed control. The original cable drums are driven through new gearboxes to give drum speeds of about 25 r.p.m. on the lower haulage and 35 r.p.m., on the upper.

All cars have screwdown brakes. Cars on the lower haulage also have governor-controlled skid brakes to bear on the concrete road at high speeds, with alternative hand operation. On the upper haulage cars have slipper brakes operating on the rails. The $\frac{7}{8}$in diameter steel cables on the upper haulage run on guide pulleys exposed between the rails; the $1\frac{1}{16}$in diameter cables on the lower haulage run in conduit between the rails.

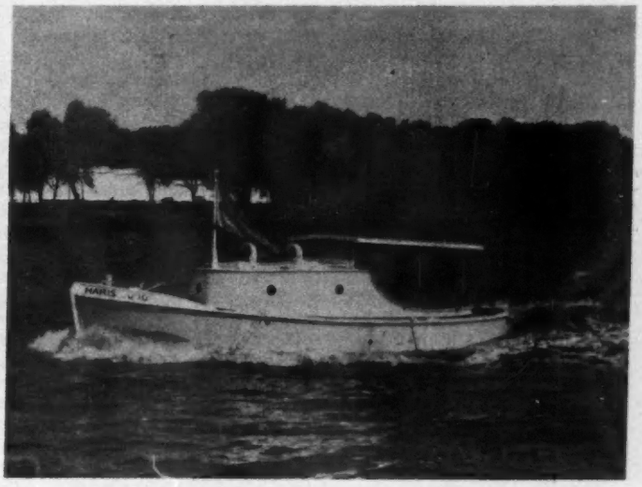
There is telephonic and bell communication between the half-way station and the cars by an overhead wire and trolley poles. At the half-way station (ILLUSTRATED ABOVE) each drive has its drum controller, tachometer, telephone, bell communication, emergency stop button and hand-operated screwdown brake on the coupled winding drums. Each drive has three main safety devices: a weight-operated brake, held off by an electro-hydraulic thrustor when the power circuit is made, is applied by pushing the emergency stop button; a centrifugal trip on the motor breaks the power circuit at 15 per cent overspeed, withdraw the thrustor, and there are electrical interlocks between screwdown hand brake "power-on" push-button and control handle

Annual overspeed tests, required by the Ministry of Transport, are done through V-belts, via a layshaft driving the other end of the first motion shaft of the gearbox. Bolts which normally couple this shaft to the brake path on the motor shaft extension are withdrawn and the V-belt drive then gives enough speed to apply the car brakes, while the weight-operated brake can still be applied in an emergency. The new drive is estimated to save about £1400 in a season.





Motor tug "Blackboys"



Launch tug "Haris"

Recent Small Craft

Among the smaller craft which have recently gone into service are an 80ft, high-speed passenger launch for Lake Maracaibo and two river tugs, one for barge towing on the river Thames and the other for service in Sudan.

High-Speed Passenger Launch

With the extension of oil drilling operations further out into Lake Maracaibo, involving distances up to 75 miles, the Compania Shell de Venezuela decided to acquire a new launch capable of carrying up to sixty passengers at about 35 knots. The order for the new craft was placed by Shell Tankers, Ltd., with Vosper, Ltd., and the latter company prepared the design after on-the-spot investigations into requirements and conditions. A craft having a length overall of 80ft, by 19ft 9in breadth moulded and 9ft 2in depth moulded was decided upon, while the power plant adopted was two Napier "Deltic" eighteen-cylinder two-stroke diesel engines each developing 1620 b.h.p. at 1500 r.p.m. The welded steel hull is of hard chine form specially designed to avoid slamming and provide comfortable riding conditions. Above the main hull is a superstructure of welded aluminium alloy and incorporating, as seen in our illustration, a steering position which is well forward. Companionways to port and starboard in the wheelhouse lead down from the wheelhouse to the passenger saloon which has seats for fifty-six passengers, the seats being arranged in three rows on raised platforms, one to port, one to starboard and one on the centreline. Seats for four more passengers are provided in the wheelhouse in addition to the crew of three.

Ventilation is natural throughout, aided by two 8in centrifugal fans which supply the passenger saloon and one 4in axial extractor fan for the toilet. Navigational equipment includes a Pye radio, one 11in and two 9in searchlights and an aircraft pattern compass. Steering is effected through a Mathway electro-hydraulic gear operating the twin spade rudders, which can be controlled manually in the event of a power failure. Electrical requirements are met by a 1·5kW 24V d.c. Lister generating set floating a battery of 130A hours capacity at a ten-hour rate. In addition there is a 3·25kW generator driven from a power take-off at the forward end of the starboard main engine. A total of 1220 gallons of fuel is carried in two tanks each of 540 gallons capacity placed to port and starboard at the forward end of the engine and a reserve tank of 140 gallons capacity sited on the centreline at the aft end. This quantity of fuel gives the launch an endurance of eight hours at 35 knots.

The Napier "Deltic" Mark 18-25K engines installed are a commercial version of the engine used for naval purposes and derated to give longer intervals between overhauls. Both engines are identical, since full power can be transmitted in either direction, and drive the propellers through an integral reversing gearbox and Napier vee drives. Incorporated is a device which enables "astern" to be selected from "full speed ahead" so that it is possible for the launch to come to rest in about two boat lengths. The machinery has fully automatic starting equipment and is controlled from the wheelhouse. The engines have a bore of 5·125in by a stroke of 7·25in by 2 and a compression ratio of 16·4 to 1, the brake mean effective pressure being 80·9 lb per square inch with the engines developing 1650 b.h.p. at 1500 r.p.m. continuous rating. The corresponding brake mean effective pressure at a maximum power of 1815 b.h.p. at 1550 r.p.m. (one hour rating) is 86·1 lb per square inch. The specific fuel consumption is 0·386 lb per brake horsepower per hour.

On official trials the launch attained a maximum average speed of 37·35 knots over the measured mile.

High-speed passenger launch on speed trials

Two River Tugs

The Thames Tug and Lighterage Company, Ltd., has recently added new building to the maintenance work usually carried out at its Brentford yard. For its own lighterage business on the river Thames the company has constructed a tug which has a waterline length of 43ft by 13ft 6in breadth moulded and 6ft depth moulded, the draught aft being 5ft 6in and the loaded displacement 34·5 tons. Of round bilge form the tug named "Blackboys" and shown in our illustration, has been built of heavy scantling steel while the fenders, carried in steel saddles are of 12in diameter rubber, moulded to shape and fitted at bow and stern. Vickers-Armstrongs, Ltd., supplied the hand hydraulic steering gear and both the stern gear and propulsion motor were provided by John I. Thornycroft, Ltd. The Mark RZ6 diesel engine has six cylinders of 4·75in bore by 6·5in stroke and a maximum brake mean effective pressure of 89·5 lb per square inch and is a four-stroke unit with direct injection. The engine, which is fresh-water cooled with an external heat exchanger, is rated

at 100 b.h.p. at 1500 r.p.m. and drives a four-bladed bronze propeller through a 3 to 1 reverse reduction gear. On trial the tug attained an average speed of 8·9 knots and recorded a bollard pull of 31·5 cwt at 1300 r.p.m., while turning circles to port and starboard were completed in 41 and 40 seconds respectively. With the engine in reverse the tug was brought from full ahead to rest in 18·7 seconds. In service the tug will be used mainly for towing up to six barges.

The second vessel completed recently by the company is the steel launch tug " Haris," illustrated on page 221. It measures 30ft 6in on the waterline by 10ft beam by 4ft 9in moulded depth and has a draught aft of 3ft and a loaded displacement of 10 tons. The hull, built of steel, is of single chine design and is propelled by a Thornycroft RNR.6 four-stroke, direct-injection fresh-water-cooled diesel engine, with external heat exchanger, having six cylinders of 4·12in diameter by 6in stroke and a maximum brake mean effective pressure of 92·5 lb per square inch. The engine which has a normal brake horsepower of 76 and speed range of 450 to 1600 r.p.m. has been derated to 65 s.h.p. at 1300 r.p.m. to suit local tropical conditions and drives a three-bladed propeller of 30in diameter by 24in pitch through a 2 to 1 reduction gear. Running free the tug reached a mean speed of 8 knots and turning circles of two lengths in diameter were completed in 28 seconds while the average time, with and against the tide, taken from full ahead to point of gathering sternway was 14½ seconds. On bollard trials a pull of 15 cwt was recorded with the engine developing 49 s.h.p. at 1000 r.p.m. Both tugs were designed by Courtney, Hughes and Partners, Ltd.

Marine Turbine Control System

RECENTLY Weir Valves, Ltd., held a demonstration of the marine turbine control valves and emergency control systems which have been designed by the company. The demonstration took place at the works of Drysdale and Co., Ltd., Yoker, following proving trials at the works of G. and J. Weir, Ltd., Cathcart.

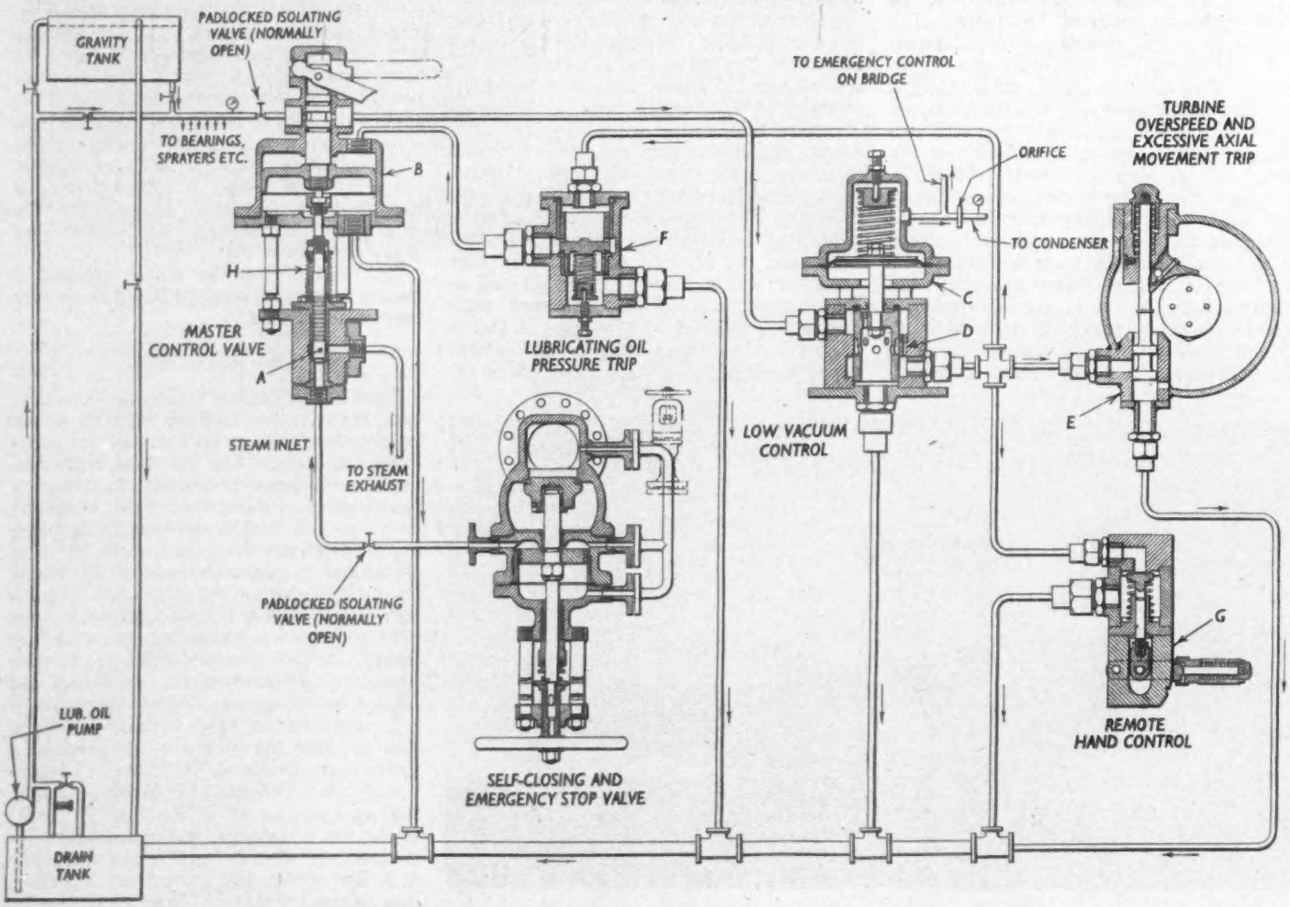
Where high temperatures are involved or where adequate lubrication of moving parts cannot be maintained the principle of simplicity is essential to ensure a high degree of reliability and efficient operation. With this in mind care has been exercised, in the designing of the marine turbine control valves, to avoid cumbersome and complicated forms and produce a unit which is simple, effective, accessible and reliable. Nevertheless, the valves are robust and have an internal form which provides maximum flow without turbulence and with minimum pressure drop. The mating surfaces of valve seats and heads have " Stellite " deposited upon them by a welding process to ensure steam tightness, trouble free service and long life, and the stainless steel valve spindle is carried in bushes and passes through a deep stuffing box packed with a heat-resisting, mica lubricated material. Swing bolts hold a combined gland and drip tray in position. The range of valves includes a self-closing and emergency stop valve, ahead and astern manœuvring valve, and an astern double shut-off valve.

In the self-closing and emergency stop valve steam from the inlet side is admitted to the piston chamber through orifices to create an approximately balanced condition when the outlet connection is closed. Loss of lubricating oil pressure, overspeeding of the turbine, excessive movement of the turbine rotor, loss of vacuum together with the operation of the emergency hand lever result in the opening of the outlet and this disturbs the balance of pressure on the piston causing the automatic closure of the valve. The closure, which is controlled and cushioned, is effected without shock and when the causes of closure are rectified the valve, being self-restoring, returns to its original operating position.

The manœuvring valve incorporates a main valve head containing a pilot valve to which is connected the operating spindle and having a skirt which provides sensitive control of steam flow at initial opening and final closing. Steam is admitted to the piston chamber and then through orifices into the annulus surrounding the auxiliary valve when the valve is closed. When opening the valve an initial movement of the spindle opens the auxiliary valve and steam then flows through the centre port in the main valve head into the discharge main to create a condition of approximate balance so that further movement can be made with little effort. The astern double shut-off valve is of globe pattern and, like the manœuvring valve, has a skirt on the valve head which gives sensitive control of steam flow.

Emergency Control System

Our line drawing shows a diagrammatic arrangement of the emergency control system which has been designed to close the



Diagrammatic arrangement of emergency control system for main steam supply

main steam supply should certain emergencies occur, most of which have been mentioned already in the notes upon the emergency stop valve. The system is interlocking and until the cause of the shut down has been corrected the turbine cannot be started again although provision is made for over-riding the interlock should conditions so warrant. There is a master controller which has to be reset after the cause of tripping has been rectified so that the system has a high degree of safety. When a trip occurs the lubricating oil supply to the system is cut so that the maximum amount of oil is available for the turbine bearings. Similar protection for the bearings is provided in the event of a fracture occurring in the oil piping of the trip system. Arrangements allow for the maintenance of the units in the system without stopping the turbine.

The action of the system, which works in conjunction with the self-closing and emergency stop valve, in an emergency is to open the auxiliary steam valve *A* on a master controller *B* and so allow steam to exhaust from the underside of the piston in the emergency steam stop valve to cause its automatic closure. All oil to the control system units flows via the master controller and is shut off there when the auxiliary valve opens. The master controller consists of a piston which is pressed down to close the auxiliary valve by the main lubricating oil pressure transmitted to it through the trip units. The supply of oil passes through a ported stem attached to the piston of the master controller and then flows via the vacuum trip unit *C* through the restricting orifice *D*. From here it is led to the trip units, namely, overspeed and excessive axial movement trip *E*, remote hand trip *G* and low lubricating oil pressure trip *F* through the ports of which it passes to the top of the piston in the master controller.

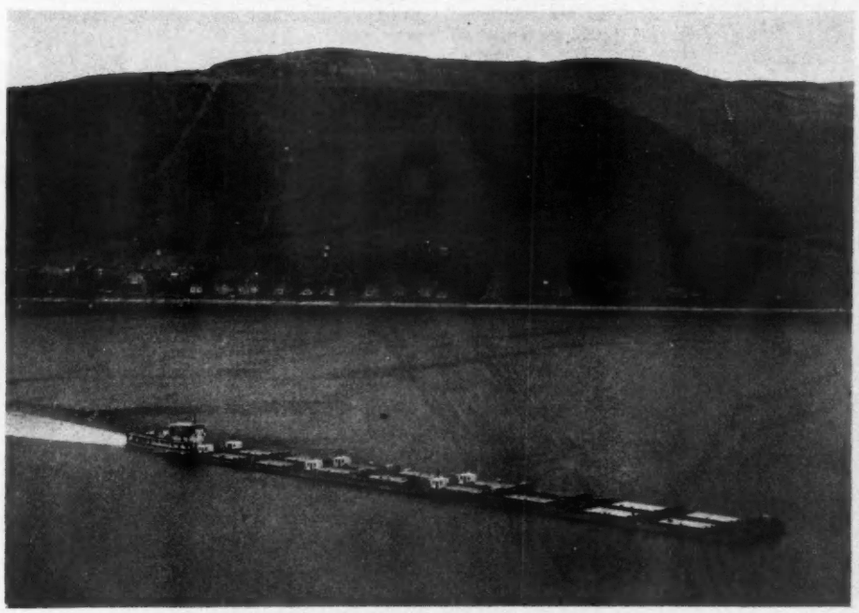
When any unit trips, the oil supply is open to drain so that the pressure in the circuit, after the restricting orifice, is lowered, thus causing the low lubricating oil trip to connect the cylinder of the master controller to drain and then the combined force of spring *H* and the steam pressure on the auxiliary valve forces the piston upwards. This movement closes ports in the stem and isolates the trip system and at the same time the steam pressure is applied to a larger area and ensures that the movement continues to the end of its travel. Once the master controller has caused the auxiliary valve to open it cannot be closed again except by manual operation of the resetting lever thus allowing the oil to flow again into the piston chamber through the transit port and the emergency units, provided these have been reset. Hence the whole system has an automatic interlock to override which the operating handle at the master controller must be held down by hand.

Pusher Tug and Integrated Barge Train

SUCCESSFUL and interesting trials, the first of their kind to take place in the United Kingdom, have recently been completed on Loch Long, Firth of Clyde, of an integrated barge train built by Yarrow and Co., Ltd., to the order of The United Africa Company, Ltd., London, and under the supervision of Goodwin-Hamilton and Adamson, Ltd. The fully integrated barge train, which consists of the pusher tug "Gongola" and eight barge units, measures 630ft in length overall with a maximum breadth of 66ft, and will operate in service on the rivers Niger and Benue, the terminal ports being Burutu, in Nigeria, and Garua, in the North French Cameroons, representing a round voyage of over 2000 miles.

A comprehensive series of model tests was carried out at the National Physical Laboratory to the requirements of the owners to determine the optimum performance of the tug and barge units which were designed for "push-towing," as distinct from the conventional methods of towing barges astern or alongside, and the present fully integrated train is the result of these experiments.

The company introduced "push-towing" to Nigeria in 1950, and developed this system from small tows of 60 tons up to one of 2800 tons.



Pusher tug "Gongola" and eight barge units on trial

The "Gongola" was launched last May. It is a twin-screw tunnel vessel specially designed for "push-tow" duties under shallow water conditions, constructed to Lloyd's highest class and in accordance with Nigerian regulations for the service intended, and the principal dimensions are :

	ft	in
Length overall	105	5
Length on load waterline	104	0
Breadth moulded	23	0
Depth moulded to main deck	7	0
Depth moulded to upper deck	14	0
Draught loaded (extreme)	4	5

The main propelling machinery consists of two normally aspirated, unidirectional "Ruston-Paxman" type-16 RPHM, Series II, marine diesel engines, each driving a propeller shaft through an oil-operated Hindmarch-Modern Wheel Drive combined reverse reduction gear, with a flexible coupling fitted between the engine and gearbox. Each engine has a rated continuous output at the gearbox coupling of 560 b.h.p. at an engine speed of 1250 r.p.m., and at this speed will be capable of developing 510 b.h.p. in the service area. Engine cooling is by fresh water working in a closed system, with independent heat exchangers. The propellers are of manganese bronze of "Unislip" design, each working in a separate tunnel.

To ensure maximum manœuvrability of the barge train, "Gongola" is fitted with two steering and four flanking rudders, all of partially balanced double-plate design, actuated by hydraulic steering gear supplied by Vickers-Armstrongs (Engineers), Ltd. The hydraulic gear consists of four steering units, two for the steering rudders and two for the flanking rudders, lever operated from a control console situated in the wheelhouse. The two steering rudders can be operated either simultaneously or independently and the four flanking rudders are coupled for operation in pairs, port and starboard respectively.

Careful consideration has been given to the general arrangement of the vessel to ensure that comfortable accommodation and other amenities are provided for the African personnel, who will operate the barge train in service. The captain's cabin is sited on the navigating bridge deck adjacent to the wheelhouse, the latter containing the control console, which, in addition to the steering and flanking rudder controls previously mentioned, includes the remote controls for the main engines, also main engine revolution indicators and electric rudder indicators. A spacious deckhouse on the upper deck forward contains cabins and a messroom for the engineers and deck officers, while a deckhouse on the main deck forward contains cabins for the crew and a switchboard room. In the house aft on this deck is the galley, stores, workshop and steering gear compartment.

On the main deck forward is an anchor windlass, while aft is a warping capstan, both of hydraulic pattern manufactured by Vickers-Armstrongs (Engineers), Ltd.

Electrical power is provided at 220V d.c. by three Ruston and Hornsby auxiliary sets, each incorporating a Mark 2YCZ diesel engine, developing 15 b.h.p. at 1200 r.p.m. in the service area, flexibly coupled to a 10kW Allen generator. Two of the sets are each arranged to drive a Megator 15 tons per hour general service pump and a Hamworthy air compressor of 15 cubic feet capacity.

Radio telephone equipment of Redifon manufacture provides communication with the company's headquarters at Burutu and its principal stations in the service area.

Nine units form the train when operating, namely, two leading barges, four intermediate box barges, two trailing barges and the pusher tug. The barge units, which are also to Lloyd's classification, have the following dimensions, &c.:

	Leading barges, ft in	Box Barges, ft	Trailing barges, ft
Length overall	133 6	130	132
Breadth moulded	33 0	33	33
Depth moulded	8 0	8	8
Draught loaded	5 0	5	5

Each barge has three transverse watertight bulkheads forming two cargo holds and the forward and after peak compartments. No longitudinal bulkheads are fitted. The cargo hatches, each 36ft by 18ft, are fitted with 2in thick wood covers. A two-berth cabin and

galley are arranged on each box and trailing barge.

For handling cargo there are four Ransome and Rapier diesel-driven cranes, each having a turning circle of 360 deg. and capable of lifting 1½ tons at 33ft outreach. One crane is fitted on each of the four barge units forming one side of the train, positioned between the cargo hatches. The two leading barges are each fitted with a diesel-driven Emerson Walker windlass and each box barge and trailing barge is fitted with a hand-operated Barton crab winch. Danforth anchors are provided on all the barge units and the pusher tug.

When loaded to a draught of 5ft the complete train has a displacement of approximately 4650 tons and will be capable of transporting a total of 3600 tons of dry cargo.

It is recognised that "push-towing" offers advantages over the more conventional methods of handling dumb barges, the pusher tug having more control over the tow, which improves manœuvrability and reduces the risk of grounding in narrow and tortuous channels, particularly during the low water season in tropical areas. An integrated "push-tow" train also offers less resistance, so that a higher speed is obtained for the same power output, or, alternatively, the same speed can be obtained with a greater payload.

"Gongola" and the eight barge units will be prepared for delivery overseas and be towed out to the port of Burutu in Nigeria by L. Smit and Co., of Rotterdam, the four box barges being transported "pick-a-back" one on top of each of the other four barges. On arrival at Burutu the four box barges will be side launched from the carrying barges, the builders having provided suitable launching arrangements.

A second and similar pusher tub, "Yola," is building for The United Africa Company, Ltd., and this sister vessel is expected to complete her trials during the course of next month.

Hydraulic Materials Transporting Equipment

PARTICULARS have been received from Babcock and Wilcox, Ltd., 209, Euston Road, London, N.W.1, of the "Hyjector" ejector pump which has been developed for pumping a mixture of solids and water through a pipeline. A photograph we reproduce shows a model of a typical equipment for the removal of furnace ash and clinker reduced to a prescribed size from a boiler installation, and a diagram showing the principle of the pump. A pressure water supply is directed through a convergent-divergent passage leading to the pipeline. A chamber built round the passage forms a suction inlet for a mixture of water and solids, as shown in the diagram. This mixture is discharged from a storage hopper into the chamber by a jet of water from an auxiliary feed nozzle.

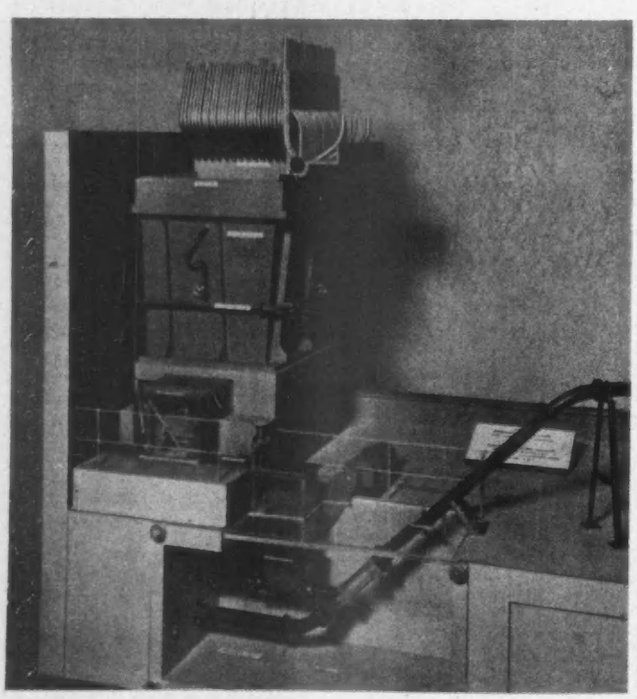
Abrasive wear is reduced to a minimum by the use of special materials. By the positioning of the jet nozzle tip out of the path of the solids it is kept free from wear and it does not interfere with the free flow of the solids, so that plugging is assisted and back washing rendered unnecessary.

For maintenance or inspection purposes the "Hyjector" can be assembled and dismantled easily as the inlet piece, throat and discharge piece are simply clamped together at each joint by four through-studs instead of bolt flanges. The joints between these parts are machined and sealed by standard gaskets made of a rubber compound. For applications where acids, alkalis or high temperatures are encountered, gaskets of special materials can be furnished to suit conditions.

Four sizes of "Hyjectors" are made by Babcock and Wilcox, Ltd., to handle solids in recommended maximum sizes of 1¼in, 2¼in, 3in and 4in, respectively. These units have respective suction inlet diameters and outlet diameters of 3in and 4in ; 5in and 6in, 6in and 8in, and 8in by 10in. The smallest size is used for handling iron pyrites rejected by coal pulverisers and the three larger sizes are generally used to handle boiler bottom ash and disintegrated slag, although they may also be used to transport pyrites. The maximum sizes of solids recommended are for average conditions and provide for the free and continuous passage of a number of pieces running concurrently. Maximum sizes of pieces are determined for special cases after all conditions are known. Before solid material is fed into the conveying system, provision is made to reduce it to size by a clinker grinder or by manually breaking oversize pieces on a grid.

The equipment has only three points of attachment when fitted in an installation and for this purpose the inlet piece has a machined bolt flange for attachment to a small feed hopper or pipe sluiceway. The jet water nozzle tip is connected through a bolt flange to the high pressure water supply line, and a sleeve coupling is used to connect the discharge piece to the transporting pipeline.

The "Hyjector" is first actuated by admitting high pressure water through the nozzle. Water is then supplied to the auxiliary feed nozzle and the solid material from the storage hopper is discharged into this stream at a suitable rate.



Model of the "Hyjector" pump, for pumping a mixture of solids and water through a transporting line

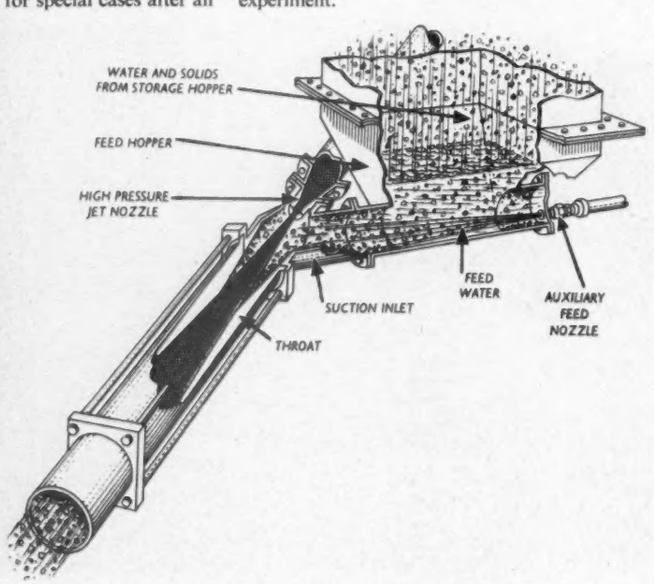


Diagram showing the construction and principle of operation of a "Hyjector" equipment

Abnormal Loads and the Preston By-Pass

THE decision of the Minister of Transport to ban vehicles carrying abnormal loads from using Preston By-pass—the first length of motorway in the country—when it opens to traffic later in the year, is criticised in the British Road Federation's monthly bulletin for August. This bulletin points out that the existing Motor Vehicles (Authorisation of Special Types) Order already provides an elaborate system of control for the abnormal indivisible load. Advance notice must always be given to highway authorities, and if the load exceeds 75 tons or its width is more than 9ft 6in the police or the Ministry of Transport have power to vary the route used and the time of movement. Indeed, for the very heaviest loads or those of exceptional dimensions, an individual Special Movement Order has first to be obtained from the Ministry of Transport before the load can go on to any road at all.

Under the Special Roads (Classes of Traffic) Order, 1958, even this controlled use of motorways by abnormal loads will be banned except for one or two specific experiments which the Minister may wish to carry out. The British Road Federation goes on to suggest that the Minister may have in mind allowing very heavy vehicles on motorways which have dual carriageways with three lanes, as distinct from Preston By-pass and, for example, the Ross Spur, which have dual two-lane carriageways. The proposed order would be unwarrantable in view of his existing powers to control the heaviest loads and because it is common sense that medium-heavy loads of more normal dimensions should use motorways without restriction. The Federation concludes that the ban is illogical and incongruous and cannot be justified even as an experiment.

SHORTER REPORTS

Control of D.S.I.R. Programmes

A CHANGE in organisation affecting two D.S.I.R. laboratories has been announced by the Council for Scientific and Industrial Research. To replace the existing research boards, small steering committees are being set up to be responsible for the research programmes at the new Warren Spring Laboratory, Stevenage, and at the National Chemical Laboratory, Teddington. Formerly, the research boards were responsible to the research council, but there was not necessarily any common membership between the boards and the council. This will not be true under the new arrangement.

Each committee consists of four members besides the chairman : two of the members are from industry and have experience of research management ; the other two are the secretary of the Department of Scientific and Industrial Research and the director of the laboratory concerned. The steering committee of the Warren Spring Laboratory is under the chairmanship of Sir Harry Jephcott and the members from industry are Dr. R. Holroyd and Mr. D. A. Oliver. The chairman of the National Chemical Laboratory steering committee is Professor C. E. H. Bawn, and the members from industry are Dr. F. Roffey and Mr. B. Topley. The committees can set up specialist sub-committees as required, to advise on the different fields of research covered by the laboratories.

Ashford Common Pumping Station

ON Thursday last, the Ashford Common Works of the Metropolitan Water Board was inaugurated by Mr. R. J. Buckingham, chairman of the Board. (The works were described in our previous issue, page 171.) This pumping station is distinguished by the installation of three gas turbines as standbys for the diesel generators, and in the course of the opening ceremony Mr. Buckingham started up one of these, the Metropolitan-Vickers 2500kW alternator. This set, which on trial in 1955 achieved a heat rate of 19,345 B.Th.U. per kilowatt-hour, in contrast to its guaranteed 20,400, is a single-shaft geared installation of great inertia, and naturally took some minutes to run up to speed. It is found that the very close governing of this set, which is able to accept or reject full-load instantaneously, allows it to run in parallel with the reciprocating engine plant. Since its trials, when it was stripped and found free from deposits, although the Board does not use air filters, it has run about 500 hours without attention to any components other than the combustion chambers.

The second set (seen partly assembled beyond the M.V. alternator in the illustration on page 172, *ante*) was built by the English Electric Company ; it completed its guarantee trials in January last, was then returned to Whetstone, and is not yet completely installed. This set, it will be recalled (details of the contracts for all three sets appear on page 337, March 25, 1949), is nominally of 1875kW, but in the expectation that more power would be available an alternator of 2250kW was fitted ; the guaranteed consumption of 21,325 B.Th.U. per kilowatt-hour was improved upon in a trial in which the gas turbine was loaded beyond the nominal power and it is expected that a rating of 1975kW will actually be adopted. The gas turbine may be regarded as an E.M.27 P of 2200kW shaft power (see page 305, August 30 last), but with slight differences ; for instance, lubricating oil pump and starter motor are separate components.

The third set, a 2500kW Brush free-turbine, direct-drive turbo-alternator, has run only in the maker's works, but it is expected to be serviceable in the very near future.

There was also run during our visit to the works one of the General Motors two-stroke oil engines. It was to be noted that, when the doors in the soundproofing enclosure were closed, the fact that the plant was running was imperceptible in the pump house. Inside the enclosure, it was noticeable that the engine was afflicted with both fuel and lubricating oil leaks, but this was attributable, we were informed, to the fact that it had not been tightened down after a rebuild ; all three engines had had war-time gudgeon pin assemblies replaced after a failure in one unit. A Walter Kidde crankcase atmosphere monitor is installed. The diesel alternators are used for twelve-hour peak-chopping, because of their much lower fuel consumption, and because the jacket water can be fed into the station heating accumulators, but the gas turbines, which were installed principally in order that the Board might gain experience of such prime movers, might well be used when it is required to supply power to another pumping station. The two free-turbine sets are not expected to run in parallel with the direct-drive alternators, but may well be paralleled with each other to accelerate from rest a big motor that can be held on load by one alone.

British Part in International Nuclear Conference at Geneva

A SCIENTIFIC and a commercial exhibition will be held at the same time as the second international conference on the peaceful uses of atomic energy in Geneva (first two weeks in September). One of the main themes of the scientific exhibition will be controlled thermonuclear fusion ; British work will be represented by large-scale models of " Zeta " and " Sceptre III,"* and a working model of apparatus now in use† at A.W.R.E., Aldermaston. The U.K. Atomic Energy Authority has taken 5000 square feet of space altogether, and will also deal in its display with such matters as the reactor research programme, surveying for raw materials, research on fuel elements, instruments, reactor chemistry, and the disposal of fission products. Among the models of reactors will be one of the high-temperature, gas-cooled experiment at Winfrith Heath, and others of the civil power stations now being built for the C.E.G.B.

The U.K.A.E.A. is also occupying 3500 of the total of 47,000 square feet devoted to British displays at the commercial exhibition. Here the British section will form the largest national display. There are to be well over eighty participants in the British section, and the total number of exhibitors, including British, will be about 200. The sponsor and the co-ordinator of the British section is the Nuclear Energy Trade Associations' Conference, 32, Victoria Street, London, S.W.1.

Of the 200 British papers submitted, eighty-seven will be actually read at the conference.‡ Some titles of nuclear engineering interest are as follows :—" The Stability of a Constricted Gas Discharge," by R. J. Taylor ; " Fuel Element Behaviour Under Irradiation," by V. W. Eldred, G. B. Greenough and P. Leech ; " Experience in the Design of Irradiation Loops," by H. Cartwright, B. E. Eltham and R. F. Jackson ; " Current Re-Designs of Calder Hall," by J. B. W. Cunningham ; " The Mechanical Properties, Embrittlement and Metallurgical Stability of Irradiated Metals and Alloys," by M. J. Makin, D. R. Harries, R. E. Smallman and A. T. Churchman ; " Liquid Metal Fuel Technology," by B. R. T. Frost ; " Steam Cycles for Gas-Cooled Reactors," by W. R. Wootton and A. J. Taylor; " The Dounreay Fast Reactor—Basic Problems in Design," by H. Cartwright and J. Tatlock ; " Advances in the Design of Gas-Cooled Power Reactors," by R. V. Moore, L. Grainger and H. Kronberger ; " The Possibilities of Achieving High Temperatures in a Gas-Cooled Reactor," by L. R. Sheppard ; " Fabrication Technology of Beryllia and Beryllium," by D. T. Livey and J. Williams.

* See THE ENGINEER, January 31, 1958, page 160, and May 23, 1958, page 781.

† See THE ENGINEER, August 1, 1955, page 185.

‡ For a short prospect of the conference as a whole, see THE ENGINEER, June 20, 1958, page 943.

Resurfacing the Mersey Tunnel

THE Mersey Tunnel carries well over 30,000 vehicles a day during the summer, and 29,000 during the winter. When, therefore, the tunnel roadway had to be resurfaced, the contractor, the Trinidad Lake Asphalt Company (North Western), Ltd., had to comply with very strict traffic arrangements. All work had to be done between 9 p.m. and 6 a.m., all plant removed at the end of each night's work, and all paving joints made good.

When the tunnel was constructed in 1934, the road was paved with cast iron " setts," which, it was hoped, would be permanent, non-skid and easily cleaned. This surface eventually failed in two respects : the cast iron setts " rocked " owing to partial failure of the concrete screeding, and the surface eventually became too slippery for heavy traffic conditions. Subsequently, the iron setts were covered with a layer of cold asphalt, but even this, and the presence of two maintenance gangs every night, was not sufficient to prevent further deterioration, with the result that the decision was finally taken to resurface the carriageway with hot asphalt. The first stage was to remove the iron setts and any faulty concrete screeding. In its place a new three-layer surface was laid, consisting of 2in of asphaltic concrete, a 1in " wearing course " of hand-laid mastic asphalt, and a surface dressing of ¾in resin-coated chippings. The latter were chosen in preference to the normal application of bituminised chippings, as they imparted a light colour initially, and retained it indefinitely.

Capacitance Gauges for Measuring Liquid Content

A RANGE of capacitance gauges for measuring liquid contents has been developed by Firth Cleveland Instruments, Ltd., Treforest, Glamorgan. The " Pacitran " gauges, as they are called, belong to the class of instruments which operate in accordance with the capacitance of a pair of electrodes immersed in the fluid that is to be measured. Any change in the liquid level causes a corresponding change in capacitance and is indicated on an instrument scale normally calibrated in terms of mass.

One application is the measurement of fuel in aircraft tanks. To show the weight of fuel it is necessary to take account of density and dielectric constant, since these quantities vary widely with temperature. In the " Pacitran " gauges compensation is effected by a force balance float system which provides density correction and a continuously immersed sensing unit which detects changes in the dielectric constant of the fuel. The instrument contains a self-balancing double bridge circuit in which fuel level, density and dielectric constant appear as variable functions. Any error signal derived from the bridge circuit is amplified by a three-stage silicon transistor amplifier and is used to drive a low-torque rebalancing potentiometer, through a split-phase servo motor and reduction gearbox. A dead-beat tendency is introduced by hysteresis damping, giving a full-scale response time of about ten seconds. The indicating instrument case has a 2¾in or 3½in S.A.E. bezel.

A modified version of this capacitance gauge has been developed for measuring the contents of liquid oxygen in evaporators associated with oxygen breathing apparatus for aircrews. The instrument is built into a 2¾in S.A.E. case. It gives a full-scale reading for a change of 15pF.

Both the fuel gauge and the liquid oxygen gauge are designed for aircraft use and operate from standard aircraft power supplies.

30ft Vertical Boring and Turning Mill

A NUMBER of large vertical boring and turning mills of interesting design has been built by Craven Brothers (Manchester), Ltd., Reddish, Stockport, in recent years, and another such machine just completed, which has been specially adapted to suit a purchaser's requirements, is illustrated below. This machine is for the Australian State Dockyard at Newcastle, New South Wales, and is primarily intended for handling work up to 15ft diameter with provision for occasionally taking pieces up to 30ft diameter. It is a fixed-column mill based upon the standard Craven 25ft design, but having a 22ft diameter table and its two columns spaced out on bed wings with the cross-slide and tie beam extended to accommodate a swing of 30ft 3in diameter.

The machine is driven by an 80 h.p. variable-speed reversing motor through vee belts and a three-speed gearbox to give a table speed range of from 0·25 to 7·5 r.p.m. The main motor has a 3 : 1 speed ratio and operates from a 220V d.c. supply which is provided by a constant speed motor-generator set operating from the normal a.c. mains supply. The final drive is transmitted by two steel pinions engaging a large-diameter, single-helical gear ring secured to the underside of the table. These two pinions, which are situated at the rear of the machine at positions 90 deg. apart, are mounted on vertical shafts in the bed. They are driven from the main gearbox through a central distribution box at the rear of the bed and spiral bevel gears. The construction includes provision for setting the pinions so that they share the total driving load equally.

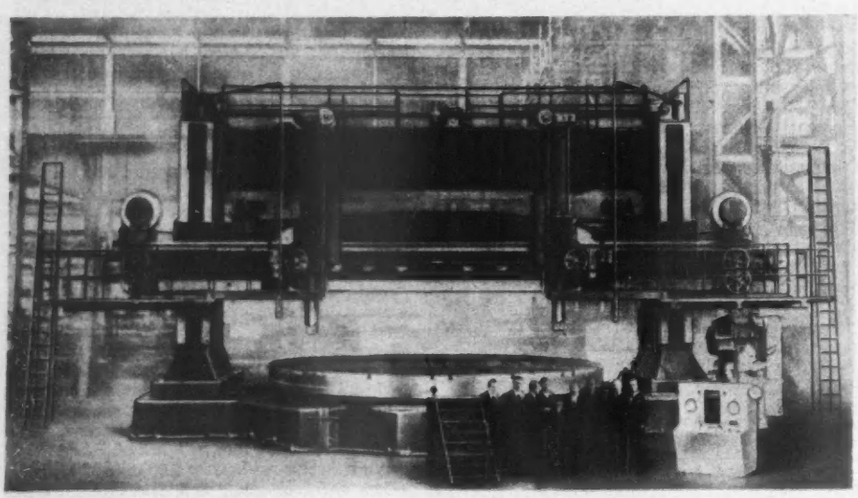
The bed is built in three sections securely jointed together and is provided with special self-accommodating levelling screws and plates. The table, also constructed in three sections rigidly secured together, has eight pairs of tee-slots for the attachment of loose jaws, and is secured to a central hollow conical cast iron spindle. This spindle runs in phosphor-bronze bearings having convenient means of vertical adjustment for the regulation of running clearance.

The vertical load of the table and workpiece is supported by two flat, concentric tracks mounted on top of the bed and fitted with phosphor-bronze bearing pads. Oil bath lubrication is provided for the spindle and tracks, with additional pressure oil feed direct to the various bearing faces from two independently-driven pumps with separate oil supply reservoirs. Electrical interlocking ensures that the oil is circulating before the table commences to revolve, and if any failure occurs in the pump motors or oil supply system, the main motor automatically stops. The temperature of the oil at eight different points in the tracks and spindle bearings is indicated in rotation upon a dial in the main control desk. If the temperature at any point exceeds a predetermined figure, an alarm bell rings and warning lamps light on the control desk.

Each cross-slide saddle has a balanced octagonal-section ram, fitted with a forged steel toolholder and adjusted vertically by means of a central screw. The rams can be swivelled to an angle of 30 deg. on either side of the vertical position and each has a vertical or angular travel of 5ft 6in. Hand adjustment of a ram vertically or its saddle horizontally can be effected by separate handwheels at the end of the cross-slide or by a single handwheel and lever-operated selection clutch on the front of the saddle.

Feed change and quick power traverse motions for the two saddles are embodied in separate gearboxes at the ends of the cross-slide. Twelve rates of horizontal and vertical feed are provided ranging from 0·007in to 0·376in per revolution of the table, and the drive to each feed box is by a separate receiver motor which is used also for quick power traverse purposes. Feed changes are made by the operation of gear levers on the feed boxes. When used for feed drive the motors receive their electrical supply from a transmitter generator coupled to the output shaft of the main drive gearbox. Thus variations in the table speed are reflected in the output voltage from the transmitter and cause corresponding variations in the speed of the feed motors. In this manner a constant feed per revolution is maintained regardless of any change that may be made in the speed of the table. It is also possible to build up the speed of one feed motor from rest whilst the other feed motor is already in operation. When used for quick power traverse purposes, the two feed motors are automatically connected to the fixed voltage a.c. mains supply and run at a constant speed.

The cross-slide is elevated by a 35 h.p. constant-speed motor on the top tie beam, and the cross-slide can be locked to the columns by separate motor-operated clamping units. An electrical interlock prevents the main motor being started until the cross-slide is locked. Full control of the electrical equipment is embodied in a desk panel and controls for the main motor and the appropriate feed motor are also provided on each saddle. These controls are duplicated in two push-button stations suspended from swivelling arms mounted on the top of the columns.

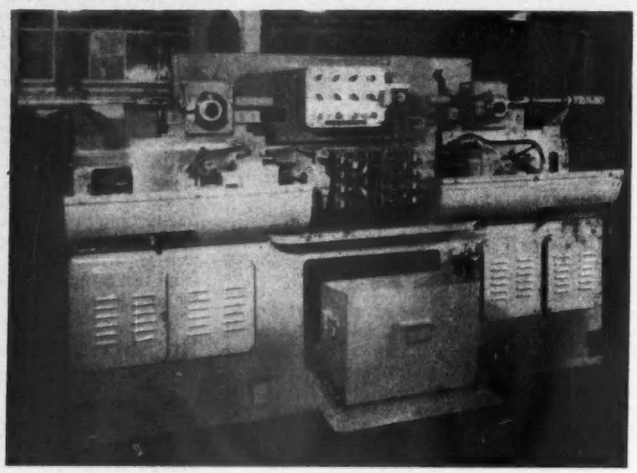


Standard Craven 25ft vertical boring and turning mill specially adapted to swing work up to 30ft diameter

Deep-Hole Drilling Machine

AN eight-spindle, high-production, deep-hole drilling machine, developed by Adcock and Shipley, Ltd., Leicester, is designed to cover the requirements of a wide range of components of different lengths and diameters. It also provides for different sizes of drills ; variations in drill speeds, feeds, drilling steps between retractions, and the drilling of blind or through holes.

The machine, as can be seen from the photograph we reproduce, has a box section cabinet base on the front face of which slides carry horizontally opposed drill heads. An indexing turret fixture is carried on trunnions between the drill heads. An electrical control panel situated centrally on the top of the cabinet contains the push buttons, control switches and a valve for controlling the rate of drill feed. Limit switches on the top of the cabinet can be set to control the depth of the drilling steps.



Eight-spindle, high-production, deep-hole drilling machine

Each drill head is driven by a 2 h.p., 1430 r.p.m. motor and, through pick-off gears, speeds from 425 to 1700 r.p.m. are available for the four spindles of a head. The feed movements of the drill heads are imparted by hydraulic cylinders and feed takes place in steps; between each step the heads are withdrawn at rapid traverse rate for swarf clearance. After each withdrawal the drills are returned to their original position at rapid traverse rate and at this point the drill feed rate is re-engaged.

A feed mechanism control box situated on top of each drill head slide houses a ratchet mechanism incorporating a masking plate. The ratchet mechanism controls the total depth of drilling of the head and the masking plate the amount of depth of drilling per step. Both settings are accomplished by operation of a dial or lever on the front of the box, dials giving direct readings of the dimension selected, so that the operator merely has to dial the depth of drilling per step and the total depth of hole required. The ratchet mechanism operates a bar carrying two trip cams and each movement of the pawl traverses this bar the equivalent length of one drilling step. The trip cams are set a distance apart equal to the length of the selected drilling step plus a predetermined amount of drill clearance, usually 0·015in. These cams operate limit switches controlling the changeover from rapid to drill feed traverse of the heads during the drilling operation. A switch in the feed control box is operated when the ratchet mechanism reaches a zero setting. At this point the maximum depth of hole has been drilled and the switch overrides a limit switch controlling the change from rapid return to rapid forward traverse, and causes the head to retire to the final out position.

Components are clamped mechanically on the two-station indexing fixture, and loading and unloading of parts is carried out at the front station whilst the components on the rear face of the fixture are being drilled. The fixture turret is hand indexed and an interlocked locating plunger prevents operation of the drill head feed if the turret is not correctly located.

Special Purpose Machine Factory

SINCE the firm of CVA Jigs, Moulds and Tools, Ltd., was established in a small factory at Portslade, Brighton, some fifteen years ago it has steadily grown, and its manufacturing facilities are now concentrated in no less than eight modern factories, having a total floor area of about 500,000 square feet, in the district. The range of products made by the firm now includes automatics, lathes, milling machines and machine accessories as well as special purpose machine tools.

We recently visited the Hollingbury trading estate to see the firm's No. 6 factory which has been specially designed and equipped for the production of special purpose machine tools. The main production floor covering some 100,000 square feet is built on two levels, the upper level being equipped with heavy duty machine tools and the lower level providing a large unobstructed area for the assembly of special purpose equipment. At the time of our visit tests were in progress on what is believed to be one of the largest in-line transfer machines yet built in this country. This machine, designed and built under the licensing agreement between the firm and the Kearney and Trecker Corporation of the United States, is some 140ft long and has fifty-one stations, of which thirty-seven are for machining operations on the head castings of four- and six-cylinder engines.

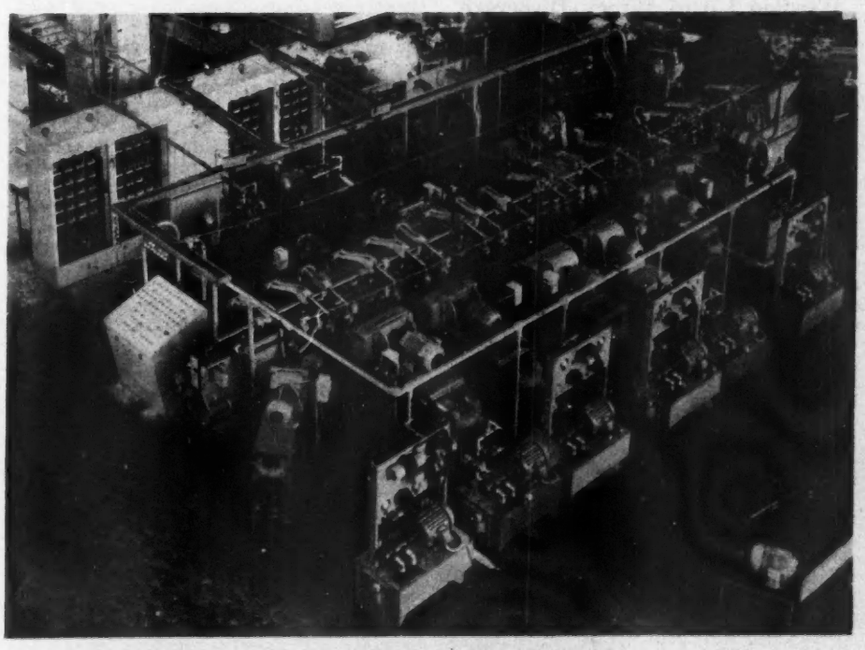
The machine is built in two sections, one for the milling and the second for the drilling, tapping and similar operations. According to production requirements the two machine sections can be connected by a four-station link-up section or used independently. When independent working is required or in case of emergency components which have been milled on the first section of the line can be "banked" in the link-up section. In the milling section the components are moved from station to station by side transfer bars which swing clear during their return stroke. In the drilling section of the line, to be seen in the accompanying illustration, the work is moved by overhead transfer bars. Each section incorporates a number of idle stations which provide sufficient space between the heads for maintenance and adjustment purposes.

The design and construction of the machine was facilitated by the use of standard CVA Kearney and Trecker milling and drilling heads, and bed, wing and column units throughout. This form of construction will enable modifications to be made or new sections to be introduced into the line if required at any future date. Each milling head is mounted on hardened and ground steel slideways and is hydraulically traversed. Their cutter quills are mounted in precision bearings and incorporate provision for up to 1½in adjustment for setting purposes. At the salient points along the drilling section there are installed inspection probes which automatically indicate on individual lamps and stop the machine should they encounter any obstructions in a hole such as might be caused by chips or a broken drill or tap.

To facilitate maintenance all of the hydraulic lines and electrical conduits on the heads are mounted externally and in addition to the individual controls on each head unit a main control desk is situated at the head of each section. When in operation the machine uses some 260 h.p. and the electrical equipment includes Crompton Parkinson motors, Igranic control gear and "Square D" limit switches.

Other special-purpose transfer machines in hand at the works at the time of our visit included a five-station rotary indexing machine with a 48in diameter table and a nine-station in-line transfer machine for milling, reaming and drilling a component.

Rubber-lined tanks in the uranium oxide extraction plant at the Hartebeestfontein mine, South Africa



Drilling section of fifty-one station in-line transfer machine for cylinder head castings

Lining Uranium Plant

Two of the major problems in uranium extraction plant are corrosion and abrasion. The process requires treatment of acid pulp and solutions in tanks with interconnecting launders, chutes, pipework, pumps, valves and filters. Some of these components have only to withstand the corrosive action of solutions, while others, where there is acid pulp, have also to resist abrasion. Various anti-acid linings were tried by the Uranium Technical Sub-Committee of the Transvaal and Orange Free State Chamber of Mines, including wood, brick, glass, sprayed compounds and stainless steel. It was concluded that rubber-lined mild steel tanks and pipework would be the most suitable. At this stage, in 1951, the Dunlop Rubber Company had already been experimenting with rubber lining techniques in conjunction with the Chamber of Mines, and the company was given the task of cladding at least four of the plants then contemplated. This required the lining of 750,000 square feet of tank surface with acid-resisting rubber, and similarly treating 100,000ft of piping, over 1000 pumps, agitators, &c., at mines as much as 132 miles from the Dunlop factory at Benoni. Some of the tanks were 45ft high and 22½ft in diameter, and others 12ft high and 50ft in diameter. It is stated that the success of the project depended largely on (*a*) the sandblasting of the surfaces to be lined, (*b*) the extraction of fumes from the tanks during lining, and (*c*) the bonding of rubber to the interior surfaces of pipes and valves. Atlas Copco portable compressors were used at the mines and the Benoni plant for sandblasting, the extraction of solvent fumes, ventilation, &c.

Compressed air was used in bonding rubber to the inside surfaces of pipes. A pneumatic expander was developed for this work. The device consists of a rubber bellows fitted to the end of a long metal tube. The latter is inserted into treated piping, and expanded by compression of the air it contains. This not only provides the pressure required for bonding, but also expels air from behind the rubber liners. In the final vulcanising process cooling by compressed air followed the steam treatment. We understand that the first four South African uranium extraction plants were completed on schedule by October, 1952. It is also reported that the various techniques developed have been so successful that they have set the pattern for practice in Canada and Australia.

SPRAYED TUNGSTEN CARBIDE.—It is announced by the Metallizing Equipment Company, Ltd., of Chobham, Woking, that tungsten carbide has been added to the firm's range of materials available for hard facing by metal spraying. For this purpose the tungsten carbide is mixed with a suitable matrix that, after fusing, gives a homogeneous coating. It is stated that the powder will give a deposit efficiency of 93 per cent, containing almost 80 per cent tungsten carbide, so that hard facing can be carried out at high speed and low cost. High stresses do not occur during cooling.

Light vessel "St. Gowan"

Light Vessel "St. Gowan"

LAST month Philip and Son, Ltd., completed the Light Vessel "St. Gowan" for the Corporation of Trinity House: the ship has an overall length of 133ft, a water line length of 114ft, a breadth moulded of 26ft 6in by a depth moulded to the main deck of 12ft 6in. Tank tests were carried out, at the National Physical Laboratory, in which the conditions simulated the worst conditions around the coasts and a hull form was produced which is considered to be an improvement on previous post-war light vessels.

Separate cabins are provided for all six members of the crew and a suite for the master, while in addition there are cabins for mechanics who may have to stay on board while carrying out maintenance work. The accommodation is heated by hot water radiators and includes a recreation room. There are two 16ft glass fibre reinforced lifeboats, hung in quadrant davits, and a Clarke Chapman electric winch for handling the boat falls. Normally the rudder is locked amidships but when being towed to and from station a Donkin hand bridge steering gear is brought into operation. For mooring the vessel on station there is a 4-ton anchor and 1¼in "Tayco" stud link chain cable, while for emergency purposes, should the ship break adrift, there are two 25 cwt anchors, having quick release mechanism, stowed in recesses forward. The cable is handled by a Clarke Chapman windlass driven by Reavell rotary air engine.

From our illustration of the light ship it can be seen that the lantern is supported on a tubular steel mast and this extends down to the top of the floors. Doors at various levels give access to an internal ladder. The lantern itself is of Stone-Chance design and the optic is a multi-catoptric arrangement having aluminium reflectors. Aluminium alloy is also used for the structure above the gimbals. An electric motor running at 1280 r.p.m. drives the main shaft at 4 r.p.m. through an Opperman gearbox, and then by means of change wheels the final speed of the optic is reduced to one revolution in twenty seconds. There are four mirrors, the candle power is 1,220,000 and a flash is produced every twenty seconds which, with the axis of the optic at 40ft above the water line, can be seen at a range of 11 miles in clear weather. Electric power for ship and lantern is supplied at 100V d.c. by two 5½kW and two 10kW generators, each driven by a Gardner diesel engine.

The diaphone, for fog signals, is mounted aft and the necessary compressed air is provided by two Reavell Q.R. 7½in by 5in single-acting, single stage quadruplex air compressors, each driven through gears at 465 r.p.m. by a Gardner diesel engine. Each compressor is rated at 200 cubic feet per minute of free air at 45 lb per square inch and the air is delivered to three storage receivers each of 190 cubic feet capacity. Air lines pipe the air to pressure reducing valves and then a 35 lb per square inch supply passes to two sounding receivers and on to the diaphone which is controlled to give three blasts of two seconds' duration every sixty seconds. Each second of blast consumes 23 cubic feet of free air.

For bilge, fire and wash deck services there is an electrically driven Megator M50 and these services are also connected to a Downton pump. Fresh water is carried in four tanks having a total capacity of 22 tons, while about 12·75 tons of fuel oil is carried in two tanks in the engine-room.

Winding Up of Wreck Dispersal Fleet

BY the end of 1940, as a result of the increasing efficiency of British anti-submarine and anti-aircraft measures, U-boats and German long-range aircraft were finding it unprofitable to operate in the vicinity of our coasts. But by that time there were already hundreds of sunken Allied and neutral ships littering the shipping lanes and coastal waters around Britain. It was essential to get rid of these encumbrances to navigation and to provide if possible a clearance of at least 45ft of navigable water. Normal salvage methods were neither economical nor practicable under war conditions and it was decided to use depth charges and other explosives to destroy the wrecks or to blast holes in the sea bed into which the hulls sank clear of the channel. The peacetime facilities available were quite unable to meet this challenge and the Admiralty accordingly formed a Wreck Dispersal Organisation, which built up a new technique in wreck dispersal. In those wartime years it was not easy to spare ships, and until the last year of the war the job was carried on by a London, Midland and Scottish Railway cargo vessel, a large German fish-carrying trawler which had been taken in prize, a 619-ton German coastal vessel, two ex-minesweeping trawlers and a forty-four-year-old Dutch Schuyt. Even so, with the aid of this ramshackle fleet the Royal Navy had disposed of 100 wrecks by 1944 despite the loss of an average of 185 days each year because of unsuitable weather conditions. Moreover, the crews of these vessels had nothing to guide them in carrying out their unusual task. They set out on their work merely with a spirit of adventure, though they soon acquired a knowledge of explosives, diving and seamanship. The invasion of Europe meant new responsibilities for the Wreck Dispersal Organisation, and the strength of its fleet was greatly augmented. The little craft went into Ostend to blast channels through the sunken ships; they went to Boulogne and coped with twenty-six ships piled on top of one another, and at Calais they carved a way through fourteen wrecks in nine days. After further work for the Army in 1945—when it made short work of twenty-seven bridges which were blocking the Rhine—the Wreck Dispersal Organisation transferred its attention once again to British coastal waters. The makeshift fleet served its purpose well, but twenty "Isles" class trawlers were converted to deal with about 500 wrecks which remained as litter of the war. It was these trawlers, with their distinguishing mark of "D.V. 2-20," and a red flag at the masthead, which have become so familiar round the coast. Two of the twenty were store carriers. These trawlers have expended thousands of charges to achieve their work, and this has, incidentally, enabled the Admiralty usefully to dispose of its obsolete patterns in depth charges. During the last eighteen years, "graves" have been dug in the sea bed for nearly 800 ships wrecked during the war. But by the end of this year H.M.S. "Steepholm," the last of the trawlers specially converted for the purpose will have buried her last wartime casualty and the Admiralty's Wreck Dispersal Fleet will be wound up.

Multi-Skip Dumper

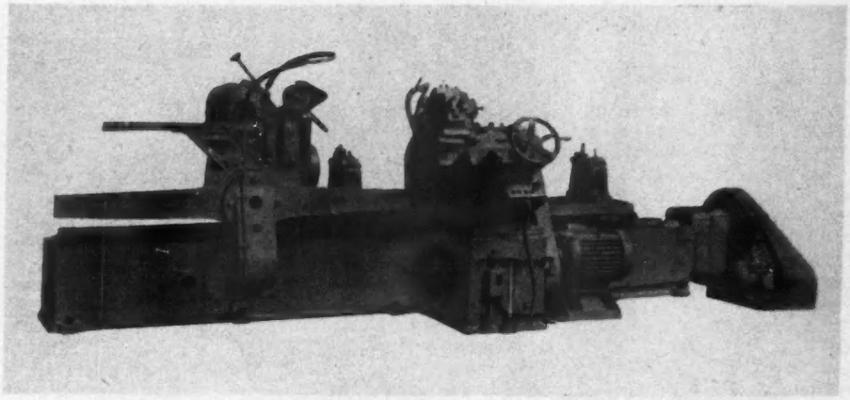
WE illustrate a dumper made by Thwaites Engineering Company, Ltd., Cubbington, near Leamington Spa, which is designed for use with a number of interchangeable free-standing skips. By using a number of skips on a working site the machine itself can be maintained in constant service without the loss of time normally involved whilst the more usual integral skip is filled.

The machine is driven by a Petter AVA2 diesel engine and is fitted with a hydraulically operated jib. This jib has a wire rope and hook by which the skips are hauled on and off the front frame members and also tilted when being emptied. When the machine is driven up to a skip, as shown in the illustration, the jib hook is coupled to the eye at the top rear edge of the skip. As the jib is raised by the hydraulic cylinder the skip is hauled up the rollers of the front member until two projecting spigots at its base register and

Multi-skip dumper with interchangeable skip ready to hook up

automatically lock in recesses in the frame. When the machine has been driven to the delivery site the skip is tipped when it rotates about the spigot centres as the jib hook is lowered. An empty skip is released by the operation of spigot lock catches ; it can then be lowered into any required position by the jib.

The makers supply alternative designs of free standing skips for handling liquids or solids, and bottom or side discharge skips are also available. When used on excavated sites the machine can be arranged for raising skips from 12ft below ground level. With standard 10 cubic feet skips the machine has a payload of 15 cwt and with a crane skip the payload is 1 ton. The maximum ground clearance of the machine is 10in and it has a turning radius of under 9ft.



Roll grinding and fluting machine with the head in the grinding position and the sine bar in the horizontal position

Marine Water Pressure Units

A RANGE of unit pressure sets for marine water systems is now being produced by Megator Pumps and Compressors, Ltd., 43, Berkeley Square, London, W.1. In these sets the pumps, control gear and all accessories are preassembled on a steel framework with all interconnecting piping and wiring completed. This arrangement, it is claimed, combines the advantages and economies of standardisation and factory assembly with the flexibility of design necessary to meet the requirements of different shipowners. The unit pressure set meets the requirements of Lloyd's Register and the Ministry of Transport, and requires only connection to the suction and delivery pipes and the electrical supply. Pressure tanks are supplied separately so that they can be installed where space is available.

Standard unit pressure sets, of which we illustrate a set using three M.8 pumps, one for fresh water, one for sea water, and one in the centre as a common standby, incorporate Megator M8 or M16 pumps, which are interchangeable with those used for many other shipboard services, with capacities up to 6 tons per hour. The suction and delivery branches of the pumps are connected into the valve assembly in the sets by means of high-pressure wire-braided flexible hoses with oil-resistant outer covers and bronze end fittings. These flexible connectors, besides being conducive to quiet operation, provide a simple and rapid means of changing over from main to standby pumps, and the design is such that fresh and sea water systems cannot be interconnected in error.

All starting, pressure, selector, isolating and other switches, also pressure and vacuum gauges, are mounted on a single control panel. The control gear and motors are fully wired and the standard accessories include combined non-return and isolating valves, by-pass relief valves, a sampling valve when a common standby pump is used, and pressure tank drains, while the pumps themselves provide the compressed air for charging the pressure tanks.

Roll Grinding and Fluting Machine

A COMBINED roll grinding and fluting machine made by Thomas Robinson and Son, Ltd., Rochdale, enables rolls up to 60in long and 24in diameter to be ground and fluted on the one piece of equipment. On this machine, to be seen in the accompanying illustration, a head, which carries both the grinding wheel and fluting tools, can be positioned for either operation simply by releasing clamping screws in the base and swivelling the complete head on its central spigot. The head is mounted at a convenient height on a base bolted to the bed of the machine, and adjustment of the head in respect to the roll being machined is effected by a handwheel.

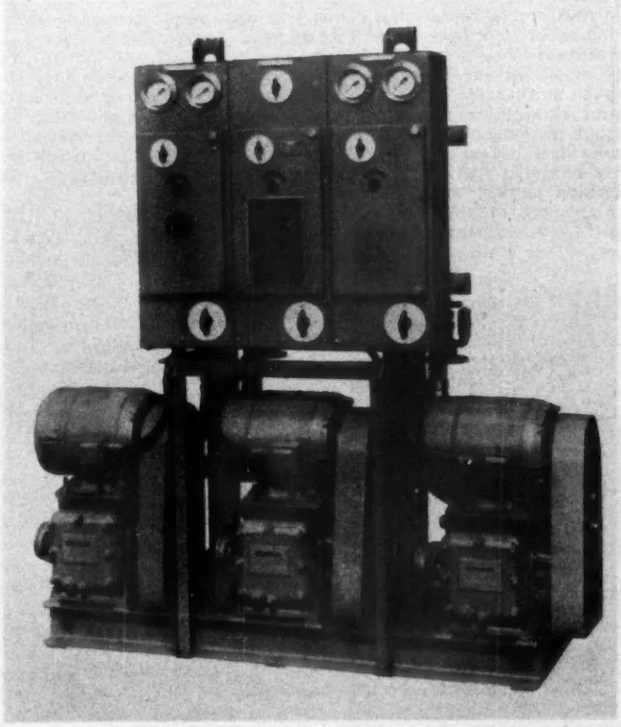
The grinding wheel spindle, running in self-lubricating adjustable gun metal bearings, is driven by vee belts from a 7½ h.p. motor mounted on slide rails.

The carbide tipped fluting tools are carried in two tool boxes, mounted at the rear of the grinding wheel assembly, and they are fitted with fine feed screws. A lever fitted to the boxes and worked by stops fixed to the table lifts the tools off the roll on the return stroke of the table. Only one tool is required for fluting thirteen or more cuts per inch, two tools being used when twelve or less cuts per inch are required.

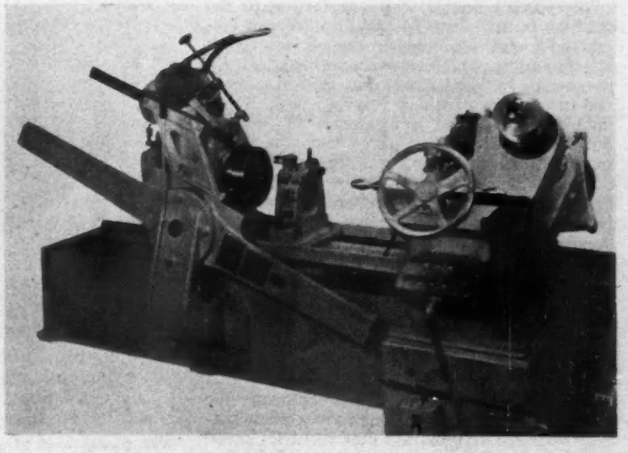
The roll is turned during the grinding operation by a 1½ h.p. motor mounted on a swing plate on the headstock. Power is transmitted by a variable speed vee-belt drive to worm reduction gearing, which drives the twisting head sleeve and chuck through a dog clutch. Engaging of this clutch disengages a dog clutch used for the fluting operation drive.

Spacing of the flutes on a roll is effected on the return stroke of the table when a pendulum lever is lifted by a steel slide, and causes a pawl to engage a ratchet wheel, moving the wheel a preset number of teeth. This turning movement is transmitted to the chuck by bevel gears and a worm and worm wheel, giving a positive feed to the roll. An adjusting screw allows fine flute spacing adjustments to be made. In spiral fluting operations the roll turning movement is effected through the chuck by a block attached to the bottom of the worm gear casing. This block slides in the slide of a canting sine bar. As the work table moves backwards and forwards, the block moves the casing up or down, to turn the chuck through the worm and wheel.

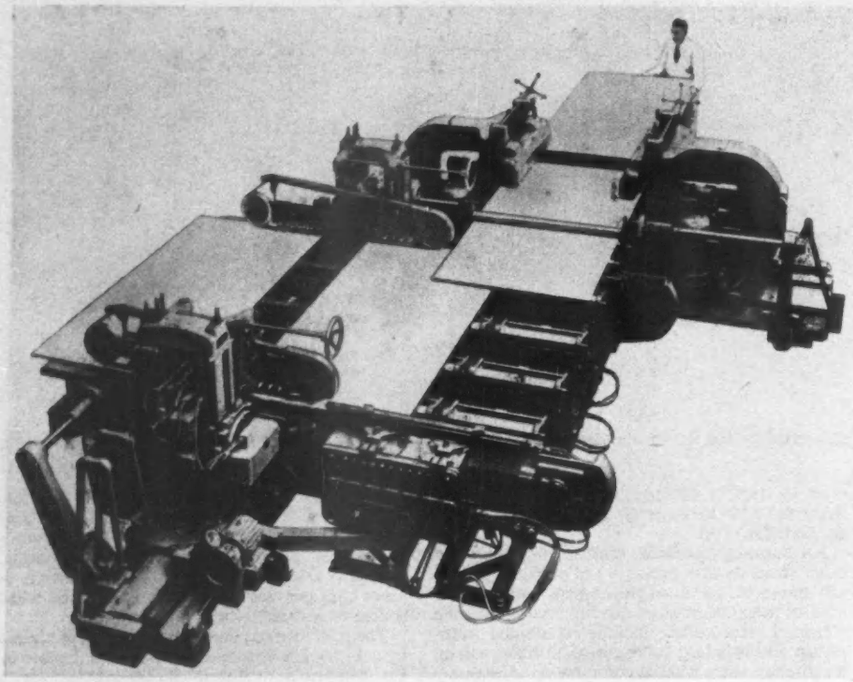
Two adjustable stands fitted to the table, which support the roll during the grinding or the fluting operation, are fitted with self-aligning bearing vee blocks and are fitted with adjusting screws, by which roll spindles can be aligned with the chuck. An electric switch mechanism, which can be operated either manually or by stops on the table side, controls a 2 h.p. reversing motor which drives the table through a two-speed gearbox. One table speed is used for fluting and the other for grinding. The gearbox, mounted at the bed end, is directly connected to the table drive screw.



Unit pressure set incorporating three M.8 pumps



Roll grinding and fluting machine set for spiral fluting



Sawing machine for trimming four sides of boards or plastic sheet material

Automatic Four-Sided Board Trimming Saw

A NUMBER of designs of automatic four-sided trim saws for use in the board and plastic industries have been developed by Wadkin, Ltd., Leicester. Included in this type of equipment are machines which incorporate four adjustable saws and are capable of trimming boards of any size between 15ft long by 5ft wide. A typical infeed double trim saw of the new design which incorporates dual chain feeding mechanism is illustrated above. This feeding mechanism, similar to that used on the automatic feed of the Wadkin straight edger, ensures accurate cutting and, as feeding dogs are not used, facilitates the cutting to width of material having irregular edges on all sides.

The infeed side of the machine has a fixed and a moving headstock to enable panels between 18in minimum and 48in maximum width to be handled. Four rates of feed of 35ft, 50ft, 70ft and 100ft a minute are provided. The two 14in saws are driven by 10 h.p. motors and will cut to a maximum of 2½in deep. If required, two additional motorised cutter spindles can be built into this infeed section of the equipment for edge grooving or moulding both sides of the panel.

The second double trim saw section of the machine is basically a Wadkin double end cut-off saw, with feed chains carried on beams attached to the dual headstocks. One headstock is movable by hand and power motion along a bed to cater for panels of varying length from a minimum of 5ft to a maximum of 8ft 6in. Smaller sizes can be handled by removing one or more sections of the roller transfer assembly.

The roller transfer unit consists of two fabricated beds carrying four rollers on each bed between the beams of the second machine, and one intermediate roller on each bed between the outfeed of the first machine and the first chain beam of the second machine. These intermediate rollers also have an adjustable top pressure roller to aid in the transfer of the panels. All the rollers are chain driven from the back shaft of the first machine at a slightly higher feed speed.

The transfer rollers located between the beams of the second machine have a pneumatically operated rise and fall movement for dropping the panels from the track level of the first unit on to the track of the second. This movement, which is actuated pneumatically by a trip fence, permits each board to ride above and overlap the preceding one, whilst transferring from the first saw section to the second. This arrangement, by avoiding any pause in the feed mechanism, ensures maximum rates of production. All the roller stands comprising the transfer unit are adjustable along their beds for varying panel sizes. Provision is made for accurately squaring a panel before passing it to the second pair of saws by means of a pair of pneumatic end pressure units, against which the board is squared before coming under the pressure controls of the second machine. These end pressure devices automatically pre-set after the squaring operation and reset after a board has passed over them in readiness for the following board. The 14in diameter cut-off saws on the second machine can be canted for angular cutting. The headstocks on this unit can also be fitted with additional heads for side grooving and moulding. The top pressure device on the second unit is a continuous belt backed by a series of individual spring rollers to provide a positive feed with precision cutting, and allowing for variations in stock thickness.

An alternative machine assembly in this range embodies an infeed lift with an automatic infeed device and intermediate saw assemblies to enable a series of cuts to be made both longitudinally and across a board as it moves through the machine, and it finally discharges the multiple panels on to an outfeed hoist.

Continuous Mining Machine

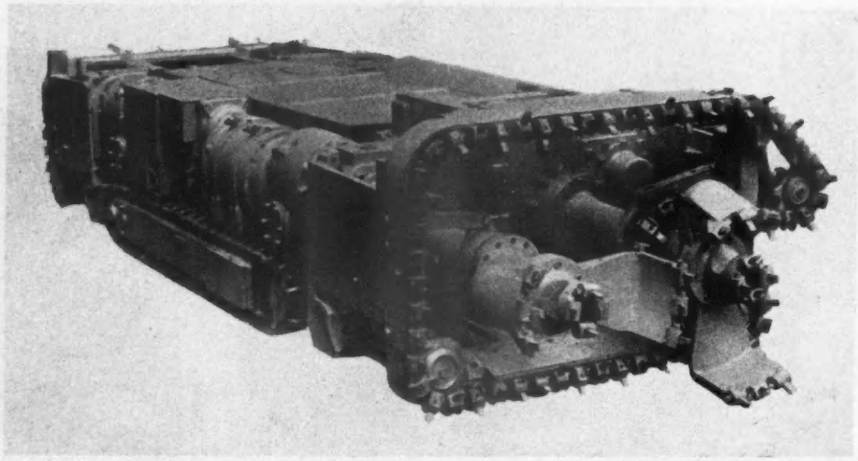
WE have received particulars of a prototype design of a Joy-Sullivan longwall continuous mining machine which is undergoing field trials in the East Midlands Division of the National Coal Board. This machine has not yet been named by its makers, Joy-Sullivan, Ltd., Cappielow, Greenock, but is generally known as the longwall "Buttock Miner."

The new machine, illustrated herewith, cuts a web of 5ft, so that it is capable of cutting the whole length of a face and finish in the stable hole. It is mounted on independently driven chain tracks and, being double-ended, the change time otherwise incurred in "flitting" is eliminated. In operation, the machine works on the buttock it has created and cuts back and forth from one end of the face to the other.

The mining heads at each end of the machine are pivoted and controlled hydraulically for vertical movement to enable them to follow undulations in a seam. Each head comprises two borers and a frame or loop-cutter that profiles the cut, finishing the bottom, face side and top. A cross conveyor incorporated in each head delivers the coal to an adjacent face conveyor.

A 100 h.p. water-cooled motor drives the boring arms and cutter chains through an overload clutch and suitable gearing. Only the head actually cutting or loading is operated at any one time. Power for the hydraulic pumps which drive the traction motors, the conveyor motors and head positioning jacks, is supplied by a separate 15 h.p. motor. The pump for the traction drive is of variable capacity for providing advance in either direction at speeds up to 4ft 6in per minute. The tracks may be driven forwards or backwards independently or in unison, making the machine highly manœuvrable.

The frame cutters of the heads are adjustable for the required height of cut, and the trailing head is retracted in height and width on the face side during working to permit a clearance at the rear of the machine. On reaching the stable hole the machine may be pushed over into its new track by hydraulic jacks operated from the machine, a method of repositioning which saves time in the stable hole and eliminates steering. The overall length of this prototype machine is 18ft and it weighs 15 tons. Its controls are situated on the waste side projecting over the face conveyor.



The cutting head at one end of longwall "Buttock Miner," showing the two borers and the frame or loop cutter that profiles the cut. Coal is fed back on to the cross chain conveyor, a section of which can be seen below the left-hand borer

Industrial and Labour Notes

Exports and World Trade

The July issue of *Bulletin for Industry*, prepared by the information division of the Treasury, contains a review of world trade. After expanding rapidly for five years, the *Bulletin* says, the trade of the free world slackened in the last quarter of 1957, and in the first quarter of 1958 was 8 per cent lower in value than a year previously. The United Kingdom share of exports of world manufactures, after declining up to 1957, has now risen slightly.

The fall in world trade so far, the *Bulletin* points out, has been mainly in the exports of the primary producing countries, the United States and Canada. The levelling off in world industrial activity in 1957, combined with a continued growth of raw material production, led to a rapid decline in the prices of raw materials. The demand of the primary producing countries for manufactured imports, however, has so far remained high, observes the Treasury, at least in total, and has been financed in part by a drawing down of their reserves, e.g. sterling balances held in the United Kingdom by other sterling area countries.

Exports from the United Kingdom were 5 per cent lower in value than a year before ; but about half of the drop was a consequence of the dock strike in June. The exports which have increased most, the *Bulletin* adds, have been engineering products. Exports of cars to the U.S.A. were 70 per cent higher than a year earlier (other shipments have in total declined), and deliveries of aircraft to Canada were four and a half times higher.

Although exports from the United Kingdom in the first quarter of 1958 were lower than a year earlier, the *Bulletin* explains, its share of world exports of manufactures increased from 18·5 to 19 per cent. The main reason for our larger percentage was the sharp drop in exports from North America ; the share of the U.S.A. fell from 25·7 to 23 per cent, and Canada's share from 5·5 to 5·1 per cent. The United Kingdom's share increased in line with the rest of the O.E.E.C. countries, but less than that of Japan and Germany, and for the first time since 1953 has not shown a fall.

Industrial Congestion

In reply to a question about industrial congestion in certain parts of the country, and of the need for new industry in others, the President of the Board of Trade, Sir David Eccles, stated in a written answer in Parliament last week that it was not the practice of his department to issue industrial development certificates—save in the most exceptional circumstances—for firms wishing to set up new factories in the more congested parts of the country. The certificates issued in those places were almost entirely for extensions or efficiency projects which it would be uneconomic to separate from the existing buildings.

Sir David said that in future he proposed to examine all such applications, both for new buildings and for extensions, even more critically than in the past and to extend the practice at present applied in the Greater London and Greater Birmingham areas to other parts of the country where unemployment was low. This might mean, added Sir David, refusal to allow a project to go forward in some particular place even though the labour could be found. But there were other places where the need for new industry was much greater, and it was those in particular that he hoped to benefit from this decision. Sir David admitted that the location of a new development in one of those places might result in a firm having to bear increased costs both in building the new factory and in connection with the movement of its plant or its key workers, or in the marketing of its products. It was to help to meet such problems that the Distribution of Industry (Industrial Finance) Act had been passed.

Sir David said in conclusion that the new arrangements meant that in such localities Government assistance for new projects would be given by the Treasury acting on the advice of the Development Areas Treasury Advisory Committee. Although the Development Fund would not therefore operate for the alleviation of unemployment, it would have a role to play in rural areas, particularly in Scotland and Wales, where the prevention of depopulation was the main problem.

A list of the places where Government assistance under the Distribution of Industry (Industrial Finance Act), 1958, would be available was appended to the President's statement.

Iron and Steel Scrap

In answer to a question in Parliament last week the Parliamentary Secretary to the Ministry of Power, Sir Ian Horobin, stated that the Government had decided that the public interest no longer required it to use its powers under the Defence (General) Regulations, 1939, to control the price and distribution of iron and steel scrap in the United Kingdom. The Iron and Steel Scrap Order will accordingly be revoked with effect from November 1, 1958.

The Board of Trade has announced, after consultation with the Ministry of Power, that as from August 5, 1958, it is prepared to consider applications for licences to export to all destinations, other than to ports or countries in the Sino/Soviet bloc, limited quantities of iron or steel scrap and old metal.

Suez Canal Surcharge

A statement about the bulletin issued by the Secretary-General of the United Nations concerning the proposed Suez Canal surcharge was made last week by the Secretary of State for Foreign Affairs, Mr. Selwyn Lloyd, in a Parliamentary reply. He said that the bulletin provided that whoever paid the transit tolls of ships using the Suez Canal should pay a surcharge of 3 per cent of those tolls to the Banque de La Société Générale de Belgique, which had been designated as the United Nations collecting agent. The surcharge would continue in force until the United Nations expenditure on the clearance of the Canal had been recovered. It was expected that this would be in about three years. The sums collected would be used by the United Nations to repay the loans made to them for the clearance of the Canal and to reimburse the United Kingdom and French Governments with the costs of the Anglo-French salvage fleet while it was under the command of the United Nations. These arrangements would take effect from September 15.

The Government attached importance to the successful working of the scheme, continued Mr. Lloyd, and it hoped that United Kingdom " toll-payers " would co-operate fully in carrying it out. The Government had undertaken in principle to reimburse United Kingdom shipowners and charterers who paid tolls, and details of how this was to be done were being worked out with the General Council of British Shipping. The Government's decision to reimburse was, however, based upon the proviso that other countries concerned, and their shipowners, co-operated in the scheme. Mr. Lloyd emphasised that the Government could not accept a position in which the United Kingdom was left to pay an excessive share, and accordingly reserved the right to review its decision from time to time.

Northern Ireland Trade

In a report issued by the Ministry of Commerce it is stated that the total trade of Northern Ireland in 1957, exclusive of trade by parcel post, has been valued at £616,296,000. The total trade for 1956 was valued at £574,780,000. The value of imports in 1957 was £318,392,000, of which £188,000,000 was for manufactured goods. Two of the largest single items of imports were machinery, £28,500,000, and coal, £17,200,000. The value of exports in 1957 was £297,904,000, which is £23,000,000 higher than the 1956 figure. The greatest increase as compared with 1956 was recorded in the exports of manufactured goods, including ships, aircraft, tobacco, ropes and twine, with an increase of £15,000,000, to £207,000,000. Compared with 1956, there was a reduction of £6,000,000 in the excess of imports over exports.

Iron and Steel

The Iron and Steel Board has published this week its annual report for 1957. In the chapter " International Relations and Import Duties," it is stated that the Board has continued to participate in the activities of the Council of Association with the European Coal and Steel Community. One of the main tasks of the Council during the period under review has been the examination of restrictions or other factors affecting the normal flow of trade in coal and steel between the United Kingdom and the Community.

In July of last year the Board published a special report on development, dealing in considerable detail with the expected growth in the demand for steel, particularly over the years to 1962. It also dealt with the new steel-making capacity then planned or already being built to meet the estimated demand. In some respects circumstances have changed, and in its annual report the Board discusses the effect of those changes. This discussion completes the account of progress made in the industry's development during 1957, only the early part of the year having been covered by the special report.

The Iron and Steel Board continued to determine the maximum prices chargeable by producers for sales in the United Kingdom of most iron and steel products (other than castings and forgings), and in a chapter dealing with " Costs and Prices " details are given of the four general determinations of maximum prices issued during the year.

A great deal of statistical material about the British iron and steel industry is given in the report. The appendices include details of development schemes which have received the Board's consent during 1957, those which have been completed during 1957, and those which have been approved and not completed at the end of 1957.

E.C.S.C. Pavilion at the Brussels Exhibition

IT is the purpose of the pavilion of the European Coal and Steel Community at the Brussels International and Universal Exhibition to demonstrate to the visitor the paramount economic importance of iron and coal in the modern economy of Europe, and the reasons for economic integration which motivated the treaty of April 18, 1951, which set up the Community of the Six Countries, and the treaty of March 25, 1957, which set up the Common Market and Euratom. The exhibition shows the composition and functioning of the various supra-national organisations, and the results obtained in the five years during which the common market for coal and steel has been in existence. The overall figures for coal and steel are shown in Tables I and II. They are taken from the High Authority's Sixth Annual Report, which was published earlier this year. The report states that steel production in the Community was expected to be doubled in the next twenty years. Dealing with the problems which this expansion would create, the High Authority underlined the need for a continued high level of investment, and for Governments to remove their indirect pressure on the industry, especially price control, which it said endangered long-term developments. The report showed that between 1952 and 1957 Community production of crude steel rose by 42·7 per cent to reach a total of 59,800,000 tons, in comparison with a rise of 32·5 per cent in Great Britain, which last year produced 22,100,000 tons. The largest percentage rise in steel production in the six countries took place in the Netherlands (70·7 per cent), followed by Federal Germany where production rose by 55 per cent between 1952 and 1957. The general industrial expansion of Federal Germany, however, was shown to have slowed down between 1953 and 1957 (49 per cent) in comparison with the period 1949 to 1953 when it expanded 75 per cent. Among the points made in the report concerning social policy are the following: The process of remodernisation was likely to continue, and with it the need for further financial aid for the readaptation of workers to new jobs. New technical developments needed more careful technical training of workers. The High Authority would ask member Governments to extend the categories of workers entitled to the European Labour Card, giving them the right of free movement in the Community.

TABLE I—*E.C.S.C. Coal Production*, 1952–57
(In millions of tons)

	1952	1956	1957	Difference 52/57	Difference 56/57
				Per cent	
Germany (Fed. Rep.)	123·3	134·4	133·2	+8·0	−0·9
Saar	16·2	17·1	16·4	+1·4	−3·7
Belgium	30·4	29·6	29·1	−4·3	−1·6
France	55·4	55·1	56·8	+2·6	+3·0
Italy	1·1	1·1	1·0	−6·4	−5·3
Netherlands	12·5	11·8	11·4	−9·2	−3·9
Community	238·9	249·1	247·9	+3·8	−0·5

TABLE II—*E.C.S.C. Crude Steel Production*, 1952–57
(In millions of tons)

	1952	1956	1957	Difference 52/57	Difference 56/57
				Per cent	
Germany (Fed. Rep.)	15·8	23·2	24·5	+55·0	+ 5·7
Saar	2·8	3·4	3·5	+22·7	+ 2·5
Belgium	5·2	6·4	6·3	+21·2	− 1·8
France	10·9	13·4	14·1	+29·7	+ 4·9
Italy	3·5	5·9	6·8	+91·6	+14·5
Luxembourg	3·0	3·5	3·5	+16·3	+ 1·1
Netherlands	0·7	1·0	1·2	+70·7	+12·5
Community	41·9	56·8	59·8	+42·7	+ 5·2

In the section dealing with relations with non-member countries, the report recorded steady progress in a number of directions. On January 26, 1957, the Agreement of Consultation with Switzerland, signed on May 7, 1956, came into force, and on September 19, 1957, the first meeting of the Committee established under the railway tariff agreement with that country was held in Luxembourg. Similarly, the agreement setting up direct through railway tariffs for community goods in transit through Austria, which was signed on July 26, 1957, came into operation on March 1, 1958. The permanent joint committee set with Austria also held its first meeting during the year under review, on June 21.

Diplomatic relations were also established by the Greek Government with the High Authority, and talks with the representatives of Scandinavian countries cleared up a number of problems which arose on the subject of the import prices of certain steels.

The growing energy shortage of the Community presented serious problems, both because of the increasing cost of imported energy, and the political danger of reliance on energy imports from certain parts of the world. The Six have decided to face together the technical revolution which atomic energy brings in its train. The High Authority itself has been made responsible for research on the development of a co-ordinated energy policy, and for making suggestions about its application.

The E.C.S.C. Pavilion.—At the Heysel Exhibition grounds, where until October 19 the Brussels World Exhibition is being held, the E.C.S.C. building stands in the southern part of the Section of International Co-operation (Fig. 1). With a frontage of about 260ft and depth of 130ft, the structure covers an area of 32,300 square feet and contains 89,300 square feet of floor space. Approximately trapezoidal in plan with the shorter parallel side constituting the front (actually slightly concave), the building consists of a flat roof suspended by cables from large portal frames which extend across from front to rear, and walls which in turn hang from the edges of the roof. The front facade is glazed while the remaining walls are opaque. The ground falls away towards the rear of the building, the difference in levels being about 30ft.

The six supporting frames each have a span of 179ft and are spaced 46·5ft apart. Each comprises a central beam sloping at an angle of 1 in 5 towards the rear, resting at each end on bifurcated legs 88ft high and spread 16·4ft at ground level, the supports resting on piled foundations. Each arch weighs 90 tons.*

The pavilion is divided up into the following principal sections: the reception hall (20in above ground level), the sections concerned with "The Institutions" and the Social Section (both 8ft below ground level), the mine and the model iron and steel works (23ft below ground level), the use of coal and steel (13·5ft above ground level), and the Future of Coal and Steel (3·5ft above ground level).

At the entrance is the reception stand where visitors obtain various descriptive folders and booklets; then comes the information counter, where questions on the Community are answered, and finally the stand from which the "invisible guides" are handed out. Visitors equipped with these receivers obtain a running commentary in their own language on United Europe, what it is and what it will be.

The section on "The Institutions," which is 46ft in height, is the centre of the Pavilion, and is divided into three halls, through which the visitor is conducted by his invisible guide. The first part shows the reasons for founding the European Community. The theme here is that technical progress and the speed of communications have made it essential to abolish the frontiers that divide Western Europe; that energy and steel resources are the key to high living standards; Europe's standard of living, which is falling more and more behind that of the United States, can and must be raised; that production on the modern scale demands large markets; the Community had already 165 million consumers; that Europe's economic and technical potential is considerable. It is explained why integration began with coal and steel (what can be produced from 1 ton of coal and from 10 tons of steel). Display panels in this section compared population and production figures for the Community, the U.S.A., U.S.S.R., and the United Kingdom. Thus total and working populations (million people) and areas (million square kilometres, shown in brackets) are, for the Community, 163·5 and 74·8 (1165·9). For the U.S.A. the figures are 169·4 and 70 (7828), for the U.S.S.R. 200·2 and 90·9 (22,273), and for the U.K. 51·4 and 24·1 (0·244).

Production of coal and steel last year stood at 248 million and 59,800,000 tons in the Community, while the U.S.A. produced 468 million and 102·5 million tons respectively; the U.S.S.R.

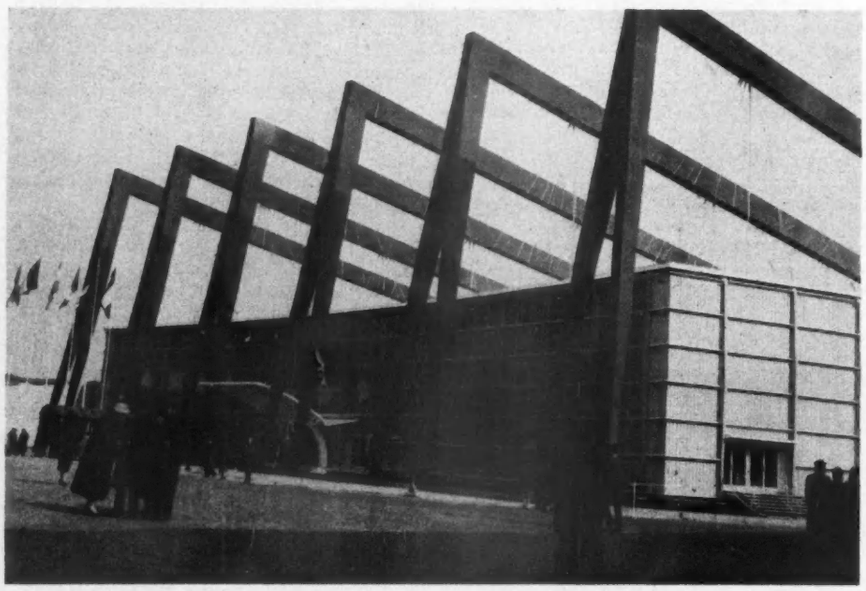


Fig. 1—The roof and walls of the E.C.S.C. pavilion are suspended from six portal frames. Exhibits are arranged on several levels. They include a coal mine with 300 yards of workings, and a 200ft 1 : 30 working model of the basic industries

* See "L'Ossature Exterieure du Palais de la CECA à l'Exposition Universelle de 1958 à Bruxelles," by A. D'Heygers. Annales des Travaux Publics de Belgique, No. 3, 1957, page 31.

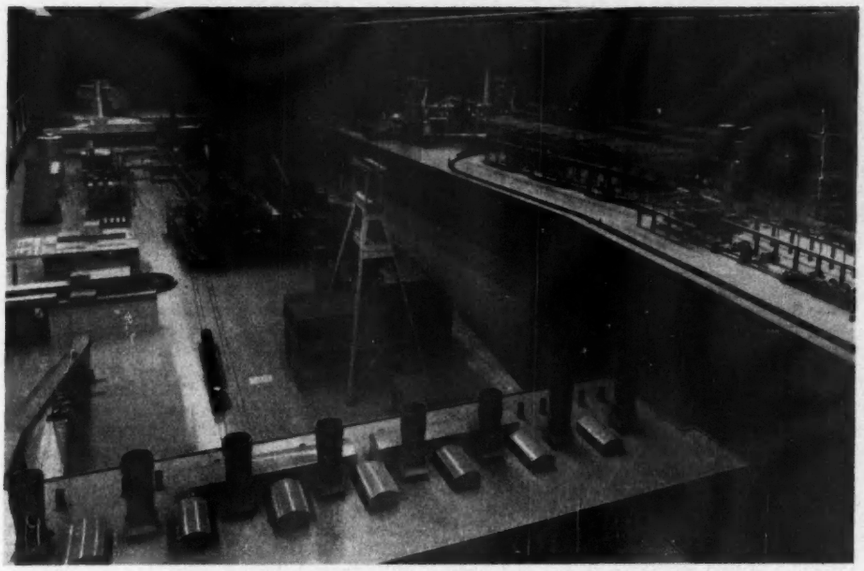


Fig. 2—Part view of basic industries' model. On the left table can be seen a power station, coal mine, washery, coking plant and iron ore mine, while on the right are an ore unloading quay and stockpile, blast-furnace, converter and open hearth steel plant, and a rolling mill

produced 325 million tons of coal and 51,000,000 tons of steel, and the U.K. 227 million tons of coal and 22,100,000 tons of steel.

The second part shows the growth of the European Community. A series of photographic panels traces the main events which led up to the establishment of the Community—the Schuman Declaration of May 9, 1950, the first Conference of the Six, the signing of the Treaty establishing the European Coal and Steel Community, the ratification by the Parliaments of the six countries. On a raised stand the Treaty is displayed, together with a separate copy of its preamble, and next to them the two Treaties of Rome establishing the Economic Community (the Common Market) and the European Atomic Energy Community (Euratom), as a reminder of the further steps that have now been taken.

The third part deals with the institutions of the European Community. The visitor can see how the Assembly exercises parliamentary control, and how the various institutions work, including the executives of the Coal and Steel Community, the Common Market, and Euratom.

The section devoted to social policy is reached by a wide corridor along which a combination of cinemascope and mirror effects gives the visitor a vivid impression of finding himself in the heart of the European Common Market.

The central theme of the the Social Section is the Community's fundamental concern with the well-being of individual citizens and workpeople, here represented by a coalminer and a steel-worker. The worker has his say in the affairs of the European Community, through the Assembly and its Committees, in which his country's representatives exercise parliamentary control over the executives and vote resolutions and recommendations ; through the Consultative Committee, one-third of which consists of workers' delegates ; and through the trade union liaison bureaux which maintain contact on the spot with the European institutions.

In this section are described the various aspects of the Community's work in the social field : readaptation of workers, illustrated by three actual examples ; freedom of movement for workers, thanks to the European labour card ; workers' wages—these are not subject to direct action by the High Authority, but because of the Community's existence, a general levelling-up of wages is stated to be taking place ; workers' health, which is the concern of the unions, the Governments and the enterprises, and for which financial aid has been granted by the High Authority ; workers' safety—the High Authority has financed a four-year industrial safety research programme, and a permanent body to ensure safety in coal mines was set up following the Marcinelle pit disaster in August 1956 ; workers' housing—plans and models show the results achieved by the two experimental building programmes and the other building projects carried out with the High Authority's financial aid ; and lastly, vocational training—photographs and diagrams illustrate what has been done in the different countries, and show how the existence of the Community has made possible an overall picture of the problems involved and brought about a most valuable pooling of knowledge and experience.

Before leaving the Social Section the visitor sees a televised representation of the model coal mine which is the next exhibit.

The Mine.—On entering the coal mine the visitor first comes to the lamp-room. He enters the cage and is immediately " wound down " the shaft. Leaving the cage at the pit bottom, he begins his 300-yard walk round the roadways, in the course of which he is able to inspect a fire-damp control post, haulage trains, mine cars, &c.

He soon finds himself at a slightly inclined coal face worked by a coal-getting plough. In another roadway a steel apron conveyor is in operation. There are to be seen a number of workings which show what underground coal-getting operations are like, both mechanical and manual, and the kind of equipment used. Machines and equipment shown are of the very latest design and nearly all of them are in actual operation. One revolutionary innovation is the explosion-proof television observation system installed below ground. The various safety devices with which the mine is equipped are also open to inspection. Miners from Community collieries are on duty throughout the Exhibition.

The Industrial Models.—Also in the basement is the model section comprising two tables, each about 200ft long, on which are displayed the models of a colliery, an iron mine, steel works and rolling mill, as well as associated plant. The models (Figs. 2 and 3) which are to a scale of 1 in 30 are shown in operation. They were built by Demag A.G., Duisburg, with the co-operation of a number of experts from Luxembourg, France, Belgium and Germany, as well as the firms Evance Coppée, Lurgi, Still and Wedag. The layout is such that the observer can see the entire range of operations from the mining of coal and ore, through the transportation of raw material to the iron and steel plant, to the manufacture of iron and steel, and the conversion of the steel produced into a variety of rolled products. The designs are based on actual plant, e.g. the integrated iron and steel works is a typical design, which in real life would have an annual capacity of 2,400,000 tons of ingot steel.

From the model coal mine the coal is taken to the washery, and thence to the coking plant, while the fines are burned in an electric power station. The coke is passed on to the blast-furnace plant, while distillation by-products are supplied to the chemical industry for further processing. Meanwhile, iron ore has arrived at the blast-furnaces from a modern minette mine with attached preparation plant. Overseas ore supplies arrive by ship and are stacked on a modern, travelling crane-operated stockpile before going on to the sintering plant. Finally all the ore is smelted in the blast-furnaces, the resulting iron being

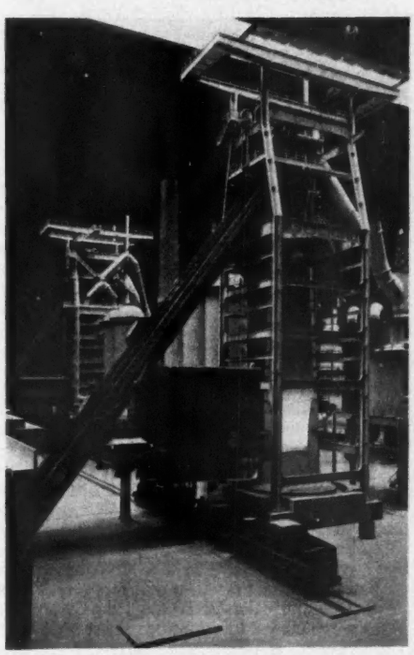


Fig. 3—Blast-furnaces from the basic industries' model, the near one being shown in section. Skips and ladle are demonstrated in operation

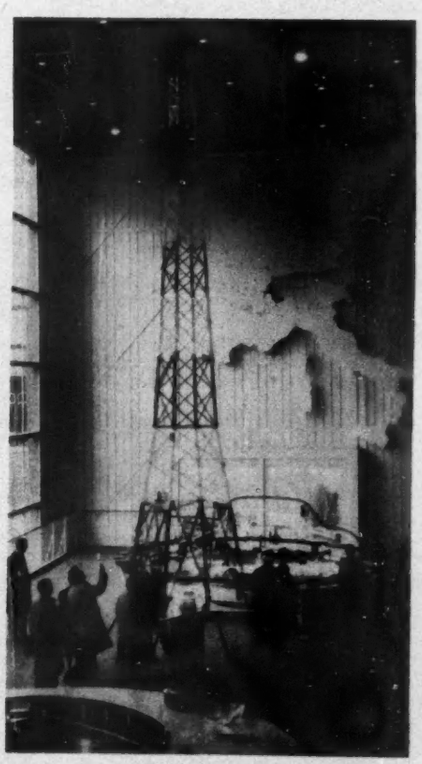


Fig. 4—In the section dealing with the applications of steel may be seen various manufactured items, prototypes and models, including a model of one of the two masts which carry the transmission lines over the Straits of Messina. The wall display shows the E.C.S.C. countries

converted into steel in open hearth and converter plants, while the production of electro steel is shown by the model of an electric arc furnace. The ingots which are the end product of the steel plants are then shown being subjected to further treatment in the blooming and slabbing mill, the output from which goes to a broad strip mill and a mill producing rolled bar and sections.

An escalator carries the visitor from this hall to the top of the next section, which is situated at first floor level, 13·5ft above the ground, and is devoted to the use of coal and steel.

The Use of Coal and Steel.—The layout here follows the pattern adopted throughout the pavilion which has been specially designed to enable the visitor to study the two aspects separately ; the coal bay is on one side and the steel bay is on the other. Here something can be seen of the extensive variety of things for which coal is used, ranging from fertilisers to pharmaceutical products, while the other side presents a vivid illustration of the theme "Steel in the Service of Man" (Fig. 4). Among the exhibits is a house made of steel entirely fitted out and furnished for everyday family life. A hall in the centre of this section is devoted to research in coal and steel, for which the High Authority gives financial aid.

Finally, the visitor descends to 3·5ft above ground level, where the last section in the pavilion gives him a glimpse of the future, taking him into the year 1975, the year on which are based the High Authority's "General Objectives" for the Community.

European Engineering Industries, 1955-57

In 1956 over eight million people in the O.E.E.C. countries (i.e. 7·5 per cent of all persons in employment) were directly employed in industrial engineering plants which accounted for over 12 per cent of the gross national product (at factor cost) of member countries combined.* In that year the gross value of production by the engineering industries amounted to about 41–43,000 million dollars, their extra-European exports totalling nearly 7000 million dollars.

In O.E.E.C. member countries there are about 58,000 industrial engineering establishments. About 1300 large plants (more than 1000 people) account for over 45 per cent of the total employment in the sector, the share of medium-sized plants (100 to 1000 people), which number less than 10,000, amounting to about two-fifths. On the other hand, only one-sixth of the total number of workers and employees are working in smaller plants.

Supply.—Throughout the years 1955–57 the European engineering industries taken as a whole and their major branches maintained their expansion. Taking price trends into consideration, the real rise in output between 1953 and 1957 is estimated to have amounted to about 40 per cent (compared with about 8 per cent recorded for the engineering industries in the United States). In 1956 and in 1957, when expansion was markedly smaller than in 1955, the rise in output remained substantially greater than that noted for European industrial production in general.

Employment increased steadily during the period between the end of 1953 and the middle of 1956, but became notably smaller from then onwards. Last year employment in the European engineering industry as a whole continued at a high level, and although some countries recorded in the last months a somewhat reduced demand for manpower in a few branches, at the end of 1957 total employment in member countries combined was greater than at the end of 1955 and of 1956. The easing in the demand for manpower mainly concerned unskilled labour, whereas in most countries difficulties of recruiting skilled workers, technicians and engineers persisted. On the whole, supply and training of manpower remained one of the most important current problems of these industries in all countries.

The rise in production and improvement of productivity were made possible by large-scale investments which totalled about 2600 million dollars in 1956, which corresponds to about 6·5 per cent of the total turnover.

The cost of raw materials and manpower—the most important cost elements—increased steadily in the years under review. Indications are that in other less important elements of the cost price structure there was also a steady rise. The only exceptions to these cost trends were the recent price decreases for non-ferrous metals.

As a consequence, prices for engineering products rose in most countries in 1955 and 1956, a trend which continued in several countries up to Autumn, 1957. Compared with the rise in costs, these price increases were only moderate.

Member countries as a whole are largely self-supporting in their supply of engineering products, imports from third countries (mainly from the United States) representing only about 3 per cent of the total apparent supply. The degree of dependence on imports is much smaller for the six Common Market countries combined than for the remaining O.E.E.C. member countries taken together.

Demand.—The share of exports in total demand varies considerably from country to country (between 10 and 40 per cent approximately). In 1956 member countries as a whole exported one-sixth of the engineering products available in Europe. Exports by the six E.C.S.C. countries combined to countries outside their area were relatively, and absolutely, substantially smaller than exports of the remaining member countries taken as a whole.

The internal demand in member countries continued to expand, though at a lower rate than exports. This seems in the main attributable to restrictive measures taken by various Governments. In 1956 these measures resulted in the levelling-off of the demand for durable consumer goods. In 1957, however, internal demand for these products increased, whereas Government measures aimed at moderating fixed capital expenditure commenced to bring about the desired effect on the demand for capital goods.

In 1955–57 export demand continued to be influenced by the interaction of a number of frequently conflicting factors such as trends in the general economic situation in major customer countries, availability of capital, accessibility of export markets. As 80 per cent of extra-European exports are directed to less industrialised countries in the free world, their trends were determined by the current pressure towards increased industrialisation in these countries.

After a sharp rise in 1955, the growth in orders decreased or came to a halt in several countries in 1956, a trend which was confirmed quite generally in 1957. So far, however, this may be considered a return to a normal order book situation, although, as a result of expansion in output, orders in hand at the end of 1957 represented on the average a smaller reserve in work than at the end of 1955 or 1956.

International Trade.—Member countries' extra- and intra-European engineering exports increased steadily in the years 1955–57. In 1956 exports to third countries represented about two-fifths of total extra-European exports, engineering imports, however, representing only 5 per cent of total imports from the rest of the world. The sharp rise of exports to the dollar area in 1956 and 1957 resulted mainly from the great rise in shipments of motor cars to the United States.

In 1956 intra-European engineering exports represented about 12 per cent of total production. Their value rose by over 50 per cent between 1953 and 1956. These exports also increased steeply in 1957. No doubt largely due to the progress made in liberalisation, intra-European engineering trade continued to expand faster than European production.

Prospects.—According to the O.E.E.C., the development of the European engineering industries during the years 1955–57 may be considered, on the whole, satisfactory. So far as the future is concerned, the fact that most Governments have found it necessary to introduce measures restraining the development of demand and, furthermore, that these measures are in principle of a temporary nature, suggests that European internal demand for engineering products will probably continue to expand.

* "The Engineering Industries in Europe." A Study by the Machinery Committee of O.E.E.C. Paris : The Organisation for European Economic Co-operation, 2, rue André-Pascal, Paris 16e. Obtainable from H.M.S.O., P.O. Box 569, London, S.E.1. Price 12s. 6d.

G.2 Becomes Critical

It is announced by the Commissariat à l'Energie Atomique that the G.2 reactor at Marcoule became critical for the first time on July 21. Criticality was achieved with a core of 22·5 tonnes as against a calculated 22·3 tonnes. Under these conditions, the pile operates at low power, in air of atmospheric pressure and without artificial cooling.

Together with the reactors G.1 and G.3 and the plutonium factory, the present reactor is one of the key items in the first French atomic five-year plan. The reactor is intended for the manufacture of fissile materials (plutonium) and the production of electrical energy from nuclear fission.

The fuel used is natural uranium, cooled by carbon dioxide at pressure. This technique was first used in France in the EL.2 reactor at Saclay and is carried out on an industrial scale in the British and French atomic programmes. Among reactors of this kind are Calder Hall, G.2 and G.3 at Marcoule, and the first nuclear power station of Electricité de France, now under construction at Chinon.

The difference of two years between G.1 and G.2 has made possible important technical advances, as a result of which G.2, for the same quantity of natural uranium fuel and graphite moderator, is about four times as powerful as G.1.

The total charge will amount to 115 tonnes of natural uranium and will be distributed over 36,000 cartridges, each 30cm long and placed inside the 1200 horizontal channels of the moderator. The moderator forms a cylinder with horizontal axis and, including the reflector, has a diameter of 7·8m and a length of 8·45m. It consists of 1271 tonnes of graphite subdivided into 16,402 blocks, and comprises the active centre, the reflector, and the wall. The heat transfer medium is carbon dioxide gas at 15 kg per square centimetre pressure.

The pressure vessel is of cylindrical shape and is constructed of prestressed concrete. This is the first time that a concrete container of such size has been built to withstand such a pressure. Besides containing the gas, it serves also as a biological radiation shield.

When at full power, G.2 is expected to have a thermal output of over 150MW, corresponding to an electrical output of 30MW to 35MW. The heat from the pile will be converted into steam by four heat exchangers operating at a maximum temperature of 350 deg. Cent. Electrical energy will be generated by a turbo-set of nominally 40MW.

Construction of G.2 began in November, 1955, and it is expected that the reactor will be in complete operation by the end of the year. The work was carried out by French firms under the direction of the Commissariat à l'Energie Atomique, the Société Alsacienne de Constructions Mecaniques acting as consulting engineers.

International Courses in Hydraulic Engineering

Engineers from all over the world are studying this year in the International Course in Hydraulic Engineering at the Technological University of Delft. The programme of this eleven months' course includes lectures, excursions, design work, and practical work. The participants are taking advantage of the experience and knowledge of leading Dutch engineers and of the many important hydraulic works now under construction or in operation in the Netherlands. All instruction is in English. The course will be repeated in 1958–59, beginning October 22, 1958. Special attention can be paid to one of the following chief branches of study according to the interests of the participants : tidal and coastal engineering, including harbours ; rivers and navigation works ; and reclamation engineering, including ground-water recovery. For prospectus and calendar of the 1958–59 course, containing detailed information, please apply to : The Registrar, International Course in Hydraulic Engineering, Netherlands Universities Foundation for International Co-operation (NUFFIC), 27, Molenstraat, The Hague, The Netherlands.

Ten Years of Transistor Progress in the United States

BY OUR AMERICAN EDITOR

No. IV—(*Concluded from page 197, August 1*)

The invention of the transistor, which was announced by the Bell Telephone Laboratories, of New York, in June, 1948, gave birth to a new era in electrical technology now known as "semi-conductor electronics." The following decade saw an unprecedented expansion of this new technology until to-day almost half of the American development effort in electronics is devoted to semi-conductors. Furthermore, a rapidly increasing fraction of communications and other electronics apparatus now employs semi-conductor devices rather than thermionic valves as active components. To mark the tenth anniversary of the birth of the transistor, a semi-conductor conference was held at the Bell Telephone Laboratories on June 17, and this article, based on data released during the conference, reviews some of the work of the past decade.

REPRESENTATIVE of a system which would be difficult to build without transistors because of space and weight requirements is the Data Communications System AN/USC–2, better known as the "Discrete Address," or DA, system. Data are transmitted over a single radio channel between a U.S. Navy surface vessel and as many as 100 aircraft. Data transmitted from ship to aircraft provide directions for the interception of targets and for returning to land on a carrier deck. Transmission from aircraft to ship includes acknowledgments and information as to distance and direction from ship, altitude, headings and speed. The system makes it possible to direct individual orders from a ship to the proper aircraft and to identify their messages of acknowledgment and information. The first experimental system, AN/USC–2 (XN–1), used point-contact transistors, and a subsequent development, AN/USC–2 (XN–2), uses newer junction transistors. The airborne equipment has about 220 transistors and the surface-based equipment has about 300.

The previous examples have been concerned with data transmission. Closely related as far as basic techniques are concerned is the field of digital computing and data processing. In defensive systems, computers must handle large amounts of data from which they must predict future target positions so that other computers can direct defensive aircraft or missiles to intercept the attack. In offensive weapons like a ballistic missile or a bomber, computers must compute the trajectory to the target or the proper position from which a bomb should be released. Until transistors became a factor in military systems, most of these jobs were done by analogue computers. Now, however, they are or will be predominantly digital. Typical of an application in which the use of transistors and the application of digital techniques have gone hand-in-hand is the "Tradic." Sponsored by the U.S. Air Force, "Tradic" has had as its goal the development of techniques for the use of transistors in a bombing and navigation computer. A significant result of this programme was the "Tradic" phase-one computer, completed in January, 1954. It was the first American all-solid-state digital computer in operation.

This first computer demonstrated techniques which could be used for the bombing problem. It also provided valuable life-test data on a relatively large collection of transistors. Even though the transistors were early models which were not hermetically sealed, approximately 700 transistors operating nearly continuously for two years gave a failure rate of only 0·07 per cent per thousand hours. This gave some early confirmation to the expectation that transistors would provide reliable operation. With techniques developed for this computer, a second computer has been designed to be tested in an aircraft. Known as the Flyable Model "Tradic" computer, it was designed to operate with the K5 bombing and navigation system in place of an existing analogue computer. In addition to the purely computing functions, a number of circuits associated with the radar, such as the radar range unit, used transistors. The first of two models was installed in a C.131 aircraft in the autumn of 1957 and has operated successfully.

Both of the "Tradic" computers are serial synchronous machines operating at a pulse rate of 1 Mc/s. Semi-conductor diodes perform the logic operations and point-contact transistors are used in circuits to retime and reshape pulses distorted by the logic networks. Both machines require cooling of the transistors. Closely related to the "Tradic" computers in basic circuit configuration, but faster in its operation, is a computer developed for the U.S. Navy. A task frequently required in air defence, such as protecting a fleet against bomber attacks, is the tracking of a number of aircraft targets using data obtained from a continuously rotating radar antenna. This is called track-while-scan. Position data on each of the various targets must be stored for several revolutions of the antenna. Each piece of data must be examined to see whether it is a new target or a new position of a target already being tracked. This can be accomplished by a computer in much the same way a human would do it. If a target position is a logical extension of a previous track, then it is accepted as a new position in that track. This kind of operation requires a relatively large number of similar operations on large amounts of data in a short time. To establish the feasibility of doing the track-while-scan with a digital computer using transistors, Bell Laboratories have developed for the U.S. Navy a computer which does the basic track-while-scan job. In addition, for demonstration purposes, it provides means for an operator with a joy-stick to "fly" a target which the computer then tracks. This computer has the capacity to track up to fifty targets simultaneously.

To keep the amount of equipment to a minimum, the computer uses serial synchronous techniques. A high pulse rate is required because of the large number of operations which must be performed. One of the outstanding achievements of this project is the pulse rate of 3 Mc/s obtained with point-contact transistors. Another point worthy of mention is that the circuits associated with the ultrasonic quartz delay lines, which provide the large amount of storage, use transistors for all active elements. This is the first known application of transistors to do this job. In all, about 1000 transistors are used. Probably the largest number of transistors which Bell Laboratories has assembled in one unit of equipment in its military work has been in the "Leprechaun" computer, illustrated in Fig. 18. "Leprechaun" represents the second major step in the "Tradic" exploratory development programme. It uses more than 5000 alloy-junction transistors in a computer designed primarily for laboratory evaluation and research in military computer organisation and programming. The transistors are operated at very low voltage (0·3V maximum on the collector) and low power (0·5 milliwatt dissipation). They provide both the logic or switching functions, as well as the gain, in a system called Direct-Coupled Transistor Logic. (DCTL). It is a good example of a use of transistors which takes advantage of inherent characteristics of the semi-conductor junctions and it would not be possible with vacuum valves. The resulting circuits are extremely simple combinations of transistors and resistors, and they

Fig. 18—"Leprechaun" digital computer with over 5000 transistors developed for the U.S. Air Force

allow a very orderly mechanical arrangement. The 5000 transistors require only about 20W of d.c. power. "Leprechaun" has a magnetic-core memory; it is the first large scale (1024 eighteen bit words) core memory in which the switching currents are supplied by transistors. This advance was made possible by the development of a transistor that switches relatively high currents (170mA) in a short time (1·5 micro-seconds).

All applications are primarily digital in their operation. Other transistor applications which are not digital have had as their primary goal an increase in reliability, as illustrated by an application in the "Nike Hercules" missile. When a missile is fired, it is very important that the warhead should not be exploded accidentally near the launching site, where operating personnel might be injured. To prevent malfunctions from causing a premature explosion, circuits are provided which prevent complete arming of the warhead until it is safely on its way. Elements in these circuits themselves may fail and it is imperative that such failures shall not cause an explosion. With the small size and low power required by transistors, a multipath or redundant circuit has been developed which prevents individual component failures from making the missile unsafe but still allows it to complete its mission in the normal way. This would be difficult to do within the missile with other components. The use of transistors to improve the reliability of the electronic guidance section of "Nike" has been the goal of another development programme. With "Nike Ajax" as the test vehicle, a number of models have been built and test fired with success.

Within the limits of security regulations, some generalisations about the kinds of circuit can be made. Practically all digital operations to be performed in the foreseeable future will use transistor and/or other solid-state devices. Considerable experience has been accumulated by the Bell Laboratories and its sub-contractors on a variety of digital techniques. On projects like those already described, enough experience has been gained to allow the confident undertaking of large systems of data processing, data transmission and computing. The problem of converting from physical or analogue quantities to digital numbers is always associated with digital operations. Techniques have been developed to do most of these conversions at least as accurately as existing equipment using vacuum valves. They will all use solid-state devices. Likewise, circuits which provide the tie between computers and radar sets in measurement of range, pointing of an antenna and other similar functions will all use transistors.

Equipment for supplying power to transistor circuits is now being made with solid-state components only. Where regulation is needed, transistors either provide the regulation or control magnetic amplifiers which regulate the output. Transistors of the newer kinds allow the operation of oscillators in the hundreds-of-megacycles range. Radar intermediate frequency amplifiers and video circuits have been developed. In the laboratory, most of the common circuits in military systems except those requiring high power can now be made with transistors. Getting them into production, and achieving a full realisation of the reliability which the transistor is capable of providing, have awaited a stabilising of the transistor art—an art that has been changing rapidly during the past five years. The development background is available, and with the advent of the diffusion process, which promises reliable transistors at low cost, the military applications can be expected to increase greatly.

Transistor Manufacture

When the Western Electric Company (the manufacturing unit within the American Bell Telephone System) started to manufacture transistors in 1951 it was faced with a completely new technology and a new set of manufacturing problems. The manufacturing engineer's first view of the transistor was one of excitement and anticipation. As he studied the original point-contact transistor, he saw a product simple in structure, rugged, and enclosed in plastics so that it would easily lend itself to mass production. However, it did not turn out quite that way. Problems were soon encountered in the areas of reliability, reproducibility and range of performance. Fortunately, a Bell group had already been established at the Western Electric works, in Allentown, Pennsylvania. Those were the days when the gate house of the works was made part of the experimental manufacturing facilities: transistors were placed in this non-air-conditioned area to determine whether or not their electrical characteristics would change under conditions of wide temperature and humidity ranges. They did. They were not reliable. Neither were they completely reproducible. It seemed that no two point-contact transistors behaved alike. In addition, not nearly enough transistors produced by the process met the exacting requirements. It was found that the manufactured device was being asked to perform at the peak of its capability.

These problems and other experiences were fed back to the other members of what Dr. M. J. Kelly has termed an "organised creative technology" team. As a result, point-contact transistors ultimately became manufacturable. Although they are not being made on a mass-production basis and although they cost more than originally expected, these new devices do satisfy certain customer demands, and their reliability in service has been quite good. For example, the transistor's first Bell System application was in the card translator for trunk call switching. The point-contact transistors used in this system since 1952 have a reliability history of 1,000,000 socket-hours per failure. The grown-junction transistor announced in 1952 was of considerable interest from a manufacturer's viewpoint for several reasons. In the first place, it had new ranges of parameter properties and extended the applications possibilities. In addition, grown junctions, which were understood and reasonably controlled, were substituted for the "art-techniques" of forming. Finally, and perhaps best of all, the manufacturing engineer was able to visualise an electronic product whose properties could be determined by test at an early stage of the manufacturing process.

The grown-junction transistor brought with it a new technology to be learned, involving a whole new set of processes, tests, and in many respects a new language in which "junction" was the common term. An operator could learn forming techniques in a few days, but it took engineers months to learn to grow single crystals with doped layers a thousandth of an inch thick between junctions to the precision and control needed for this work. As grown-junction devices were put into manufacture, changes were made which improved them and their manufacturing processes. Nor were grown-junction transistors without their early reliability problems, which necessitated many changes and adoptions of new processes; and as the extreme surface sensitivity was learned, the simple concept of plastics encasement was dropped in favour of a vacuum-tight, metal-to-glass sealed container.

Working together, the engineers of Western Electric and Bell Laboratories solved these and many other problems. They developed electro-etching, thus making unnecessary the costly solutions of hydrofluoric, nitric and acetic acids which could be hazardous to both man and machine. Automatic bonding of the base contact was visualised, and a machine was built by the Laboratories to establish that this could be done. A round can design was introduced in place of the initial oval design as an aid to ultimate automatic manufacture. A machine for making these devices was planned and built, as shown in Fig. 19. In spite of problems with reproducibility (in the junction grown in the bar) and range of performance (frequency and power), which affects demand, the machine produces units, and automatic semi-conductor production is a step on the way to reality. The grown-junction transistor has an excellent field record in an application where it is operating well within its range of performance. As used in the hard-of-hearing set amplifier, the 70,000 units in the field have resulted in only one known failure in two years of operation.

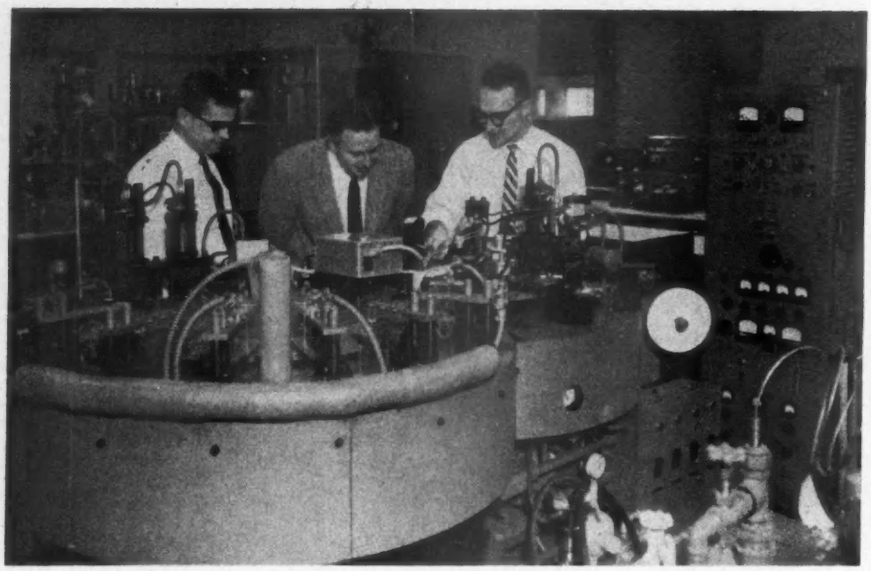


Fig. 19—Machine for the automatic assembly of transistors installed at the Allentown works of Western Electric

In 1955 a new transistor technology, the alloy process, was introduced to meet the needs of systems employing digital techniques for which the grown-junction transistor was not suitable. The very first projects for experimental electronic switching required transistors having greater reliability and better performance than any semi-conductor device yet devised. As manufacturing experience was gained on these devices on a production basis, it became clear that the alloy technology processes, though involved, were capable of the requirements requested of them. It was found that these alloy transistors could be process tested at many points during manufacture and that controls could be initiated which would make the devices reproducible and reliable. In the manufacture of alloy-junction transistors, for the first time in semi-conductor manufacture, art was being eliminated in favour of process controls. Material could be selected for optimum yield, alloying pellets could be sized and sorted for use with wafers of measured thickness to produce uniformity at alloying, alloyed wafers could be process tested, and feed-back data was used to correct alloying time and temperature.

The resulting uniform sub-assemblies reduced the number of fall-outs at later processing test points so that work was not performed on defective units and little material was discarded. The result—transistors were produced which satisfied the requirements of performance. The electronic switching systems engineers report that they have tested, under operating conditions, more than 400 of the units for over a year without a failure. New applications have arisen and more are expected as increasing volume and continuous effort reduce costs.

Low cost is not a problem of the manufacturing engineer alone. Designs and processes which can lead to low cost are to a large extent related to the original concepts in research and development. The effort of the "organised creative technology" team will fail if it cannot produce a suitable end product at a reasonable cost. To produce transistors at a low cost, stabilised designs and high yields are required and, until these considerations are met, low-cost devices produced on a mechanised basis are not possible. If one has a stabilised design, the "organised creative technology" team will refine that design and its processes, increase the yields and achieve low cost. Applying what was learned from the production of transistors for the electronic switching system units, a process has been developed to load alloying jigs semi-automatically and, as an alternative technique, alloying pellets are also being attached by a rapid "tacking" operation. Cumbersome base-wafer mounting brackets have been eliminated to produce a simple structure capable of handling more power than its prototype. New techniques for making electrode contacts, at present a tedious hand process, have been developed. These and other refinements lead to a low-cost transistor processed on a semi-mechanised basis.

In the meantime, the development engineers have introduced junction formation by the diffusion process. This appears as an additional technology to be learned and controlled, but with an encouraging and stabilising note: it suggests common material, common technology and control through understanding and measurement. As already mentioned, in the "early days"—ten years ago—the transistor was envisaged as a simple, rugged, low-cost device which was to be easily mass produced with reproducible, reliable and wide performance characteristics. With what has been learned over the past ten years, and what is promised by the diffusion technique, it appears that the goal is at hand. The uniform basic material may well be silicon, which is less affected by temperature and is readily available on the earth's surface. The common technology will be diffusion. Slices instead of wafers will be processed so that the cost per junction becomes small. Controlled and very thin diffused layers can be produced, thereby extending the range of operation. The number of different devices will be reduced. As a result, fewer processes and techniques will be needed and high yields will more quickly result. Then more complete mechanisation will be possible and lower-cost semi-conductor devices will be a reality. The manufacturing engineer's work becomes increasingly more important, for transistors are being made in growing numbers to satisfy demand for initial systems applications, and more particularly for use in development circuitry for radical new electronic telephone systems. It is significant that in ten years the transistor has been developed to the point where it can compete performance-wise and cost-wise in many applications with its forty-two-year-old competitor the vacuum valve.

Future Developments

In Fig. 20 is shown the relative yearly cost of transistor development in the Bell Laboratories from 1948 to 1958. During this period it grew by a factor of 40; whereas the total Laboratories' development budget slightly more than doubled in the same decade. Can one correlate these curves with known research achievements? The first sharp rise from zero in 1947 to the reference value of 1·0 in 1948 and to about 1·3 in 1949, was, of course, the technological response to the basic invention. This period was further stimulated by the development of techniques for growing single crystals. The rise from 1·3 to 10, from 1950 to 1952, was the response to the theoretical prediction and experimental proof of junction transistor principles. This period was also stimulated by zone purification of germanium and the development of alloy junction techniques. The third rise from 1955 to the present represents an appraisal of the relative and lasting importance of diffusion-silicon research results in 1954. If one examines similar curves for military transistor development, or for other fields such as for thermionic valves, one finds a similar pattern; the only difference is in speed of response and length of intervals between steps.

The essence of transistor electronics has been the search for understanding and control of minute impurities in otherwise perfect crystals of germanium and silicon. To-day, with the addition of the diffusion-silicon technology, practically all of the barriers to "new art" electronics have been removed in principle. One can say that the present technology of these materials is based upon a sound and broad scientific base—as is also the important diffusion method for forming them into devices capable of varied performance. Assuming for the moment that no further important research accomplishments were made in the next ten years, what is the outlook for growth? In the opinion of the Bell organisation, the major accomplishments will be: (*a*) in development: refining, simplifying and reducing the number of standard designs required to cover all major applications—both old and new electronic functions; (*b*) in manufacturing: introducing mechanisation, automation and better surface process control to reduce the cost of diffused devices of both germanium and silicon; (*c*) in applications: developing the new circuit and equipment techniques that will lead to the high level economical manufacture of large, high-speed digital systems, such as computers, switching systems and data transmission and processing systems. It follows that cost reductions will lead to further invasions of the present "valve" electronics.

It is reasonable to assume that continuing important new knowledge and inventions will be forthcoming in the next decade. What are a few of the exciting possibilities; in what areas do they lie and what might be some of their technological effects? In the field of materials, germanium and silicon are only two materials of the literally hundreds of potentially useful semiconductors. Being the simplest, they are the most completely understood. Using the basic techniques developed for these two materials, many scientists have been intensively studying a new class of inter-metallic compounds which are closely related in their structure and electronic properties to germanium and silicon. While knowledge is far from complete, recent investigations have shown that one can make a number

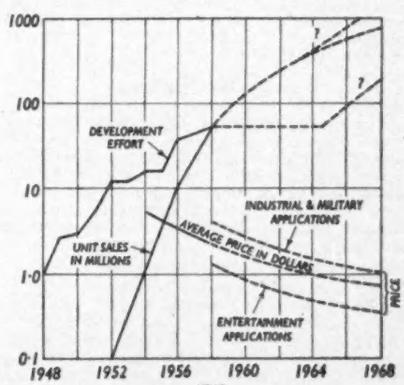


Fig. 20—Trends of transistor development, production and costs at the Bell system

of such inter-metallic compounds with a wider range of electronic properties than is obtainable with germanium and silicon. For example, theory indicates that indium phosphide and gallium arsenide devices should operate at higher temperatures of the order of 300 deg. to 400 deg. Cent., and yet provide still higher frequency and broader bandwith. Already good rectifiers have been made of these materials which verify the initial predictions.

It seems likely that new mechanisms of energy interaction within the solid semi-conductor may be discovered which will not only extend the performance, but broaden the functions of transistors even more. Already in the laboratory one can see germanium and silicon p-n junctions being operated as new variable-capacitance amplifiers at frequencies of 6000 Mc/s. Theory predicts no serious limitations down to millimetre wavelengths and noise performance much lower than that possible with the best electron valve. Preliminary experiments are verifying these predictions. One new effect that may play an important part in both continuous wave and digital electronics is avalanche-multiplication and electronic-voltage-breakdown in a p-n junction. Excess electrons or holes crossing a p-n junction, at sufficiently high reverse voltage, gain excess energy and generate secondary hole-electron pairs and form a densely charged plasma. These breakdown effects are currently used to make voltage regulating devices. Such effects have exceedingly short time constants, of the order of 10^{-11} to 10^{-12} seconds. When such effects are confined to a single microscopic region of the crystal, these micoplasmas have shown an ability to generate microwave energy and perhaps may be adapted to amplification into the millimetre wave range. With such short time constants, they may provide the switching devices for computing speeds up to 1000 Mc/s.

Most vacuum valves and transistors perform the many complex functions of communication through complex circuitry and their simple ability to rectify and amplify. Already in the laboratory one can see evidence of the coming versatility of solid-state electronics in performing complex functions within a single physical structure with a minimum of external circuitry but with the transistor's small size, very low power and its high reliability. Single p-n-p-n diodes are simple but effective switches, oscillators, amplifiers and memory elements. When a number of them are formed in a proper way into a single small piece of silicon, one obtains a pulse counter, coder, register or memory array. One final device example: the p-n junction, when operated in the avalanching reverse biased condition, becomes a light emitter and possibly a light amplifier. It requires no great stretch of the imagination to foresee million-bit photographic plate memories being interrogated by such devices.

In the field of manufacturing techniques, the protection of the semi-conductor surface to obtain the intrinsic reliability of the bulk semiconductor is one of the most expensive parts of manufacture. Moreover, present methods are mostly empirical and thereby costly because of this lack of basic understanding. With the powerful tools and scientific challenge now developing in surface physics and chemistry, the way is open for research to develop within the next decade the same kind of understanding of surface behaviour as the last decade brought for the bulk properties of semi-conductors. When this comes to pass, it will make electronic devices even more reliable, and eliminate the costly processes which significantly affect reliability, yield and cost. Such developments should enable the makers to dispense with the costly piece-parts and labour now associated with vacuum baking and capsulation.

Gas Turbine Engines for Launches

Two high-speed launches designed for offshore petroleum drilling operations are being built each powered by two 500 h.p. Solar "Jupiter" gas turbines provided by the Solar Aircraft Company, San Diego, California. One boat, under construction at the yard of Higgins Inc., New Orleans, has an aluminium alloy hull of length 52ft, and is designed to carry twenty-five passengers at 40 m.p.h., with the turbines arranged for a Vee-drive. The second boat, which is being built by Sewart Seacraft Inc., Berwick, Louisiana, is 55ft long and will carry fifty passengers at 35 m.p.h. for open sea operations with the turbines arranged for a conventional drive.

Personal and Business

Appointments

MR. G. P. BALFOUR has been appointed managing director of Stockdale Engineering, Ltd.

MR. H. L. LLOYD has been appointed general manager of the Roballo Engineering Company, Ltd.

THE NATIONAL COAL BOARD has announced that Mr. A. E. Crook has been appointed chief engineer (production).

MR. W. CLARK, works director of the John Bull Rubber Company, Ltd., has been appointed to the board of Metalastik, Ltd.

MR. J. FRANK TUCKER, managing director, has been appointed chairman and managing director of Bull's Metal and Marine, Ltd.

MR. H. E. COX, A.M.I.E.E., general manager of the Rugby works of the British Thomson-Houston Company, Ltd., has been appointed a director.

ARMSTRONG SIDDELEY MOTORS, Ltd., has announced the appointment of Mr. Sidney Allen, M.I.Mech.E., F.R.Ae.S., as chief engineer for all Armstrong Siddeley products except motor-cars.

THE BRITISH OXYGEN COMPANY, Ltd., announces that Mr. P. S. Beale has been appointed a director; Mr. R. J. Barritt has been appointed chief executive, engineering division, and will take up his duties on September 1.

C.A.V., Ltd., has announced the following appointments of area managers :—North-eastern area, Mr. W. H. Simpson ; north-western area, Mr. M. J. Reynolds ; south-western area, Mr. R. H. Lewis, and central and south Wales area, Mr. D. Brown.

MINISTRY OF TRANSPORT AND CIVIL AVIATION has appointed Mr. M. M. V. Custance to be a deputy secretary in the place of Mr. A. H. Wilson, who has retired. Mr. Wilson has taken up a new appointment in the Ministry as adviser on commercial air transport.

BRITISH TRANSPORT COMMISSION announces that Dr. F. T. Barwell has been appointed electric traction engineer (research), electrical engineering department, British Railways central staff. Mr. H. L. Preston has been appointed senior technical assistant (inspection).

MINISTRY OF LABOUR AND NATIONAL SERVICE announces that Sir Wilfred Neden, chief industrial commissioner, will retire from the public service on August 24. Mr. P. H. St. John Wilson has been appointed to succeed him with a rank equivalent to deputy secretary.

THE BRITISH ALUMINIUM COMPANY, Ltd., announces that Mr. P. T. Ensor, formerly general manager of the Canadian British Aluminium Company, Ltd., has now returned to the United Kingdom and has been appointed assistant to the commercial director, Mr. G. W. Lacey.

Business Announcements

W. E. BRAY AND CO., Ltd., Faggs Road, Feltham, Middlesex, has changed its name to Bray Construction Equipment, Ltd.

A. D. TACK RAGS AND ADHESIVE DUSTERS, Ltd., Stafford Street, Dudley, Worcs (P.O. Box No. 28), has changed its name to Anti-Dust Services, Ltd.

CLIMAX MOLYBDENUM COMPANY OF EUROPE, Ltd., states that as from September 1, its address will be 2, Cavendish Place, London, W.1 (telephone, Museum 8818).

WINN AND COALES, Ltd., in collaboration with its main Canadian agents, announces the formation of a new company, Denso of Canada, Ltd., 47, Cranfield Road, Toronto.

CROMPTON PARKINSON, Ltd., states that with effect from August 11, the address of its Nottingham branch will be Crompton House, Maiden Lane, Woolpack Lane, Nottingham (telephone, Nottingham 45678).

FIRTH CLEVELAND, Ltd., has announced that a new factory for the Firth Company, Ltd., Warrington, built to replace the one destroyed by fire in December, 1957, will be brought into production from September 1.

GAMMAX, Ltd., Cecil House, 47-51, Wharfdale Road, King's Cross, London, N.1, states that it has established a new radiographic inspection service for the examination of welds, castings and machine components, under the supervision of Mr. R. J. Ford.

CHEMICAL EQUIPMENT ENGINEERING COMPANY, Stanley Hall Chambers, Castle Street, Macclesfield, Cheshire (telephone, Macclesfield 4241), is a new company which will be concerned with the design and erection of process plants, solvent recovery plants, agitation and mixing equipment, and rotary vacuum filtration equipment.

ARMSTRONG SIDDELEY MOTORS, Ltd., announces that it has completed an agreement with Beaver Precision Products, Ltd., Detroit, Michigan, U.S.A., whereby both firms will co-operate in the complete interchange of technical knowledge and manufacturing techniques in respect of Beaver's products. A new Beaver Products Division is to be opened in England under operation of Armstrong Siddeley Motors, Ltd.

COVENTRY GAUGE AND TOOL COMPANY, Ltd., and ROCKWELL ENGINEERS, Ltd., announce that they have reached agreement in principle as to a merger of the two concerns. It is envisaged, they state, that this will be achieved by the acquisition by Coventry Gauge and Tool Company, Ltd., of the whole share capital of Rockwell Engineers, Ltd. Accordingly, and subject to agreement in detail and to C.I.C. consent, it is the intention of Coventry Gauge and Tool Company, Ltd., soon to make a formal offer to acquire the whole share capital of Rockwell Engineers, Ltd.

THE WALTER KIDDE COMPANY, Ltd., in order to ensure that no misunderstanding should arise as a result of statements made in a broadcast on May 21, 1958, make the following announcement. The Walter Kidde Crankcase Monitoring Unit, which gives advance warning of explosive conditions in the crankcases of marine diesel engines, is the result of research which began in 1951. The Walter Kidde Crankcase Monitoring Unit was formally approved by the Ministry of Transport and Civil Aviation on April 17, 1958, for use in British passenger ships, and is therefore officially available to British passenger shipping.

Contracts

BRITISH EUROPEAN AIRWAYS now has approval to conclude a contract with the Aircraft Manufacturing Company, Ltd. (Airco), for twenty-four D.H. 121 aircraft. These will cost about £29,000,000 and will be delivered between 1964 and 1966. The D.H. 121 is the short-haul and medium-haul jet airliner which B.E.A. require to follow and to complement the Comet 4B airliners, of which a fleet of six is being built for introduction on their route network in 1960. Aircraft Manufacturing Company, Ltd., is the company formed early in 1958, in which de Havilland, Hunting Aircraft and Fairey Aviation are participating. The D.H. 121 will have a maximum cruising speed of more than 600 m.p.h. It is required to carry up to 100 passengers on stage lengths of about 1000 miles, and must be able to operate from airport runways only 6000ft in length. From longer runways it will operate considerably longer stages. The aircraft will be powered by three Rolls-Royce RB. 141 engines, which will be mounted at the rear end of the fuselage. The RB. 141 is a by-pass jet engine developed from the Conway but having a greater by-pass ratio. Its static thrust will be of the order of 12,000 lb.

Miscellanea

TURBOPROP OVERHAUL LIFE INCREASED.—Three months after the increase in overhaul life of the Bristol "Proteus" 705 turboprop engine to 1300 hours (page 551, April 11 last), the Air Registration Board has granted authorisation for a further extension to 1600 hours between overhauls. Engines are already being run on trial to 1900 hours between overhaul.

WRECK RETURNS.—Lloyd's Register has issued its return of merchant ships totally lost, broken up, &c., for the quarter ended December 31, 1957. Steamships lost consequent upon casualty totalled, throughout the world, fifty-one ships of 81,872 tons gross, of which six ships of 11,779 tons were owned in Great Britain and Northern Ireland. The corresponding returns for ships broken up are eighty ships of 232,293 tons gross and twenty-nine ships of 91,714 tons.

TRANSPARENT DOUBLE-SIDED TAPE.—A transparent cellulose tape, which has a highly tenacious adhesive mass both sides of the base material, is now made by John Gosheron and Co., Ltd., Vauxhall, London, S.E.11. This tape has been developed to give an extremely thin, yet strong, mounting medium where surfaces have to be joined as closely as possible. Double-sided tapes in three base materials are now available from this firm—paper and cloth (in 50-yard lengths) and cellulose (in 36-yard lengths).

MECHANICAL STOKERS ON B.R. LOCOMOTIVES.—Following a decision made last year, three British Railways standard 2-10-0 Class "9F" steam locomotives have now been fitted with Berkley mechanical stokers, and with double chimneys, to determine to what extent their hauling capacity can be increased by these means. The three locomotives are now in service in the London Midland Region, where they will undergo trials, and are based on the Saltley motive power depot. The possibility of fitting mechanical stokers to other "9F" locomotives will depend upon the results of the trials.

IN-LINE INDICATORS.—In-line indicators are designed to display a selected number in clear, illuminated figures without any mechanical movement in the indicator, and with only a low-voltage electrical supply. We learn that there are two such types of indicator made by Hilger and Watts, Ltd., 98, St. Pancras Way, Camden Road, London, N.W.1. These are the edge-illuminated and the projection indicator. In-line indicators are primarily designed for panel mounting and can be assembled in banks, so that as many decades as required are displayed in adjacent windows. The line of figures appears as it would be written or printed. There is a choice of white or green light and continuous or dotted numerals.

AIRCRAFT TURBINES.—A type test at a static thrust rating of 17,000 lb has been successfully completed by a Bristol "Olympus," Mark 201 B. 01. 7) turbojet. The "Olympus" Mark 201 has the highest thrust/weight ratio of any high-thrust turbojet which has completed an official type test. Highest power previously revealed for the "Olympus" was 16,000 lb thrust for the Mark 201 (B.01.6), which is now in production for the Avro "Vulcan" Mark 2 bomber ; the completion of a type test at this rating was announced in January, 1957. Guaranteed minimum thrust figures for the Rolls-Royce "Conway" are : R.Co. 12 and 24, 17,500 lb ; R.Co. 15, 18,500 lb. The Rolls-Royce R.B. 108 engine for jet lift is now known to have a thrust of 2010 lb.

MAGNETIC CONVEYORS.—A design of conveyor made by Geo. Robson and Co. (Conveyors), Ltd., Hodgson Street, Sheffield, can be used for the elevation of steel parts of awkward shape up steep inclines where space has to be conserved. The conveyors are basically flat belt conveyors with the belt sliding on a smooth plate. Under this plate are arranged high-powered, permanent magnets, which serve to hold the materials to the belt. Heavy articles can be handled and, if necessary, the conveyors can be vertical. If the slight magnetism that may be imparted to articles is to be avoided a demagnetiser can be arranged at the discharge point. The widest conveyors of this type made by the firm to date have had 24in wide belts and have been for handling oiled strip steel "off-cuts" from high-speed shears.

LIFTING MAGNET EQUIPMENT FOR STEEL PLATES.—Particulars have been received from Electromagnets, Ltd., Bond Street, Birmingham, of lifting magnet equipment made for handling steel plates in shipyards and similar concerns. In these equipments a required number of lifting magnets are mounted along a spreader beam slung from a crane, and the use of relatively lightweight magnets enables full economic use of crane capacity. In a typical equipment supplied to the Blythswood Shipbuilding Company, Ltd., six 36in by 24in rectangular magnets are spaced along a spreader beam, and used for handling plates of up to 5 tons in weight. Each magnet weighs some 616 lb and has a consumption of about 1½kW. The firm's "Select-o-Load" control system used enables the crane operator to utilise only the number of magnets required to span the particular size of plate being handled by the equipment at any time.

MAGNETIC SWARF SEPARATORS.—An improved design of dual-drum separator for the reclamation of non-ferrous swarf containing ferrous contamination is now being made by Electromagnets, Ltd., Bond Street, Birmingham, 19. The separator comprises two magnetic drums embodying "Alcomax" permanent magnets. Vibratory feed trays provide a consistent and steady feed of the swarf on to the drums. Contaminated swarf is fed by a chain and bucket elevator into the primary feed hopper which regulates the feed on to the first feed tray by a rack and pinion operated regulation gate. The first drum removes the majority of the contamination, the slightly contaminated non-ferrous material passing forward on to the second tray which feeds it on to a second drum which removes residual non-ferrous contamination. As an additional safeguard to ensure that any fine iron which may be attached to non-ferrous oily swarf is removed, a final permanent magnetic chute is fitted over which all the non-ferrous material passes.

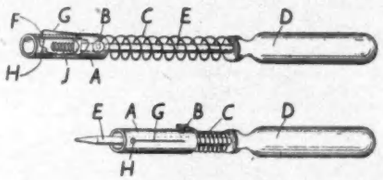
British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification. Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 3s. 6d. each.

WORKSHOP TOOLS AND APPLIANCES

797,785. August 15, 1956.—A Device for use with a Screwdriver, Cecil John Sutton, Arlington, Bibury, near Cirencester, Gloucester.

The invention relates to a device for use with a screwdriver to facilitate the attachment and removal of small screws such as grub screws, and has for its object to provide a simple and inexpensive device which may be attached permanently or temporarily to a screwdriver to enable a screw, for example a grub screw, to be located with respect to, and driven into, a tapped hole, and to be removed with ease in places difficult of access. In the drawings the upper view is a perspective view with a part



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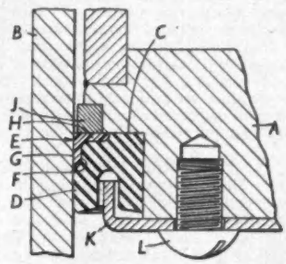
broken away of the device attached to a screwdriver for use with grub screws, and the lower view is a similar view showing the device (turned through 90 deg.) retracted for normal use of the screwdriver. A cylindrical container *A* is secured by a set-screw *B* to a coiled spring *C*, the opposite end of which is attached to the handle *D* of a screwdriver, the shank *E* passing through the spring and into the container. A plunger *F*, formed by bending a wire spring *G*, projects through a small aperture *H* in the container, the opposite end of the spring *G* being secured along a part of its length to the outer face of the container. A grub screw *J* is shown within the container, and this screw may be retained therein by depressing the plunger *F*. In use the container, with a grub screw in position, is placed over the tapped hole and the screwdriver moved against the spring until the screw engages the hole. The screw may then be screwed home. To release the grub screw the container is again placed over the hole and the screwdriver projected until the screw is engaged. When the device is attached permanently to a screwdriver and it is desired to use the screwdriver in the normal way, the container is thrust against its spring until the driver shank protrudes through the container as shown in the lower view and the container is then clamped to the shank by the set-screw *B*.—*July* 9, 1958.

POWER TRANSMISSION

797,684. June 30, 1955.—U-Section Ring Sealing Devices, Dowty Seals, Ltd., Ashchurch, Tewkesbury, Gloucester. (*Inventor: Frank Bastow.*)

This invention relates to U-section ring sealing devices for providing a fluid tight seal between relatively slidable cylindrical elements and more particularly in rams or jacks for use at high working pressure. Referring to the drawing, a portion is shown of a piston *A* and cylinder *B* of a hydraulic pit prop such for example as shown in prior Specification No. 636,568. The piston has a stepped recess *C* for the reception of a sealing ring which in this case comprises a U-section ring *D* of synthetic rubber and a supporting ring *E* of polyamide synthetic resin. This supporting ring is L-shaped in cross section and fits into a recess *F* at the outer corner of the base of the U-section ring where it bridges the gap between piston and cylinder. The cylindrical part *G* of the supporting ring extends about halfway up the outside surface of the U-section ring in contact with the cylinder wall. The remainder of the outside surface of the U-section ring also contacts the cylindrical wall in order to make a liquid tight seal. The radial flange portion *H* of the supporting ring fits over part of the base of the U-section ring and is in contact with the base of the recess *C*. The radial depth of the flange *H* is about half the radial depth of the base of the U-section ring. The remainder of the base of the U-section ring contacts the base of the recess *C* to form a liquid tight seal. The ring *J* of aluminium or like soft metal is secured around the piston *A* at a position adjacent to the base of recess *C* so that the ring actually forms a continuation of the base of the recess. This ring projects slightly from the piston to prevent the latter from making contact with the cylinder to prevent scoring of the cylinder in use. The ring *J* is actually made as close a fit as possible in cylinder *B* having regard to the tolerance that must be allowed for the internal diameter and ovality of cylinder, since the latter is made of a commercial grade of drawn steel tubing. Thus there is very probably a small gap between the ring *J* and the cylinder and the arrangement of the sealing device is that the supporting ring will cover this gap. The sealing ring *D* and the supporting ring *E* are maintained in position by a flanged metal retaining disc *K* secured by screws *L* to the piston head. When a high pressure acts on the piston it will, in the usual way act on the interior of the U-section ring *D* since the edges thereof engage the piston and cylinder by virtue of their deflection from their normal shape, to urge the



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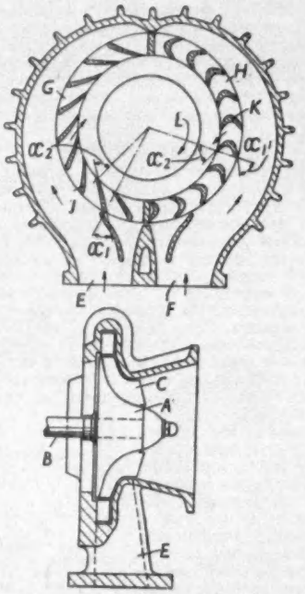
outside of this ring into sealing contact with the recess *C* and the cylinder *B*. The supporting ring by virtue of its elasticity will be urged by ring *D* into contact with the cylindrical wall and with the base of recess *C*. By virtue of its resistance to extrusion the supporting ring will bridge the gap between the cylinder and the ring *J* and will resist the action of the hydraulic pressure which tends to extrude it into the gap. This supporting ring cannot itself produce a liquid tight seal with the cylinder and the base of the recess because it is not sufficiently elastic, but its function is to reduce considerably the gap which the rubber sealing ring would have to bridge to prevent the latter from being extruded through the gap. The supporting ring by virtue of its elasticity will stretch or contract circumferentially to adjust itself to variations in cylinder diameter so that the effective gap which the rubber ring must bridge to provide an effective seal is always at a very minimum. The supporting ring is of course urged against the cylinder wall by the hydraulic pressure and is subject to considerable wear during movement of the piston in the cylinder. The fact that the supporting ring is made of a polyamide resin means that it will be extremely resistant to wear with the result that the whole sealing device has a long working life. A modified design is also shown in the Specification.—*July* 9, 1958.

INTERNAL COMBUSTION ENGINES

797,780. June 20, 1956.—Exhaust-Gas Turbines, The Daimler-Benz Aktiengesellschaft, Stuttgart-Untertürkheim, Germany.

The invention relates to distributors for radial-flow exhaust-gas turbines supplied with exhaust gases from the cylinders of internal combustion engines. According to the invention, the two parallel exhaust-gas supply ducts extend to the guide-blade ring in a plane perpendicular to the axis of rotation and symmetrically in relation to a plane containing the axis, each of ducts being being allotted one-half of the ring to the blades of which the exhaust gases from the respective ducts flow with opposite directions of rotation. The guide blades have an at least approximately constant angle of emergence around the entire inner periphery of the ring, while their angles of entry in the two halves of the ring are at least approximately equal although they are reversed in mirror-image fashion in relation to the radii on which the blades lie. With this arrangement, small radii of curvature of the ducts with resultant high frictional and bend losses can be avoided, so that high efficiency can be achieved without requiring excessive space and incurring excessive weight. In the drawing, *A* is the turbine runner which is fast on a shaft *B* and carries blades *C*. The mounting for the shaft is not shown. Two parallel exhaust-gas supply ducts *E* and *F* extend in a radial direction towards the turbine housing. The two ducts are located in a plane perpendicular to the axis of rotation and symmetrically in relation to a plane containing the said axis. The duct *E* is curved to embrace one half *G* of the guide-blade ring in the clockwise direction in the upper view and the duct *F* is curved to embrace the other half *H* of the ring in the anti-clockwise direction. The exhaust gases from the ducts *E* and *F*, thus flow around the turbine with opposite directions of rotation. The blades *J* of the half *G* have the conventional form (angle of entry α_1, angle of emergence α_2). The hook blades *K* of the other half *H* have the same angle of emergence α_2 as the blades *J* and an entry angle α_1' which is substantially equal to the angle α_1 but which is reversed in mirror-image manner in relation to the



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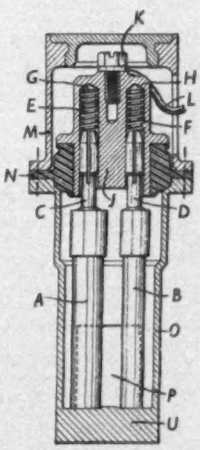
radial line on which the blade lies. As the angle of emergence α_2 is at least approximately constant around the entire periphery of the ring, uniform admission to the blades *C* of the runner is obtained. The direction of rotation of the runner is indicated by the arrow *L* in the upper view.—*July* 9, 1958.

796,662. June 4, 1956.—Ignition Devices for Combustion Chambers, Societe Nationale d'Etude et de Construction de Moteurs D'Aviation, 150, Boulevard Haussmann, Paris, Seine, France. (*Inventor: Franck Guillaume Michel Ferrie.*)

The invention has for its object an improved ignition device based on the action of a resistance which can be brought up to red heat under the effect of the passage of an electric current. In accordance with the invention, the electric resistance is formed by a rod of sintered material with a base of silicon carbide, the supply voltage being applied to the extremities of this rod. The drawing shows an arrangement in which two rods *A* and *B* of different resistances are arranged side by side. They comprise an end portion *C* and *D* engaged against the pressure of springs *E* and *F*, in housings *G* and *H* in a metallic member *J* which is connected by a terminal *K* to a conductor *L*. The metallic member *J* is enclosed in a casing *M* to which it is fixed by means of an insulating socket *N*. The rods are housed inside a metal skirt *O* of cylindrical shape, two oppositely-facing windows *P* being formed in the walls of this skirt, towards its lower extremity, so as to expose a certain length of the rods *A* and *B*. The cylindrical skirt *O* is terminated by a circular base *U*, the internal surface of which is in contact with the extremities of the rods which abut against this base due to the action of the springs. When it is desired to effect the ignition or the re-ignition of the combustion chamber in which the device is mounted, the current supply conductor *L* is placed under tension, the return being effected through the skirt to earth. The rods *A* and *B* of different resistance and connected in parallel, thus have current passed through them. The passage of this current normally heats up the rod *A* having the least resistance, to red heat, but leaves black or dark red only the higher resistance rod *B*, which is



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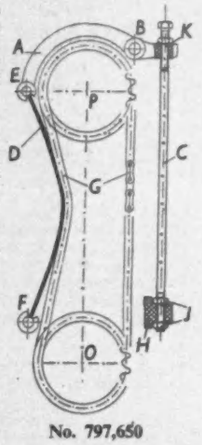
simply heated. The fuel, or the mixture of air and fuel which comes into contact with the rods through the windows *P* is vaporised by the hot but not incandescent rod *B* and is then ignited by the rod *A*. By virtue of this arrangement, the ignition is ensured in a very effective manner, whatever the external conditions may be. In case of a defect or damage to one of the rods, *A* for example, the ignition is then effected by the rod *B* which is finally brought up to red heat after a few seconds. Alternative designs are also shown in the specification.—*June* 18, 1958.

CHAIN DRIVES

797,650. November 12, 1956.—AUTOMATIC ADJUSTING MEANS FOR CHAIN DRIVES, Moto Guzzi Societe per Azioni, 28, Via Durini, Milan, Italy.

The invention concerns improvements in or modifications of the automatic adjusting means for chain drives forming the subject of Specification No. 789,438, especially means for compensating for the effect of temperature variation upon such drives and thus maintaining the tension in the chain substantially constant. The invention is applicable with particular advantage to chain drives for distributor shafts, cam shafts or the like controlling the operation of valves or ignition means in internal combustion engines. The drive illustrated in the drawing is generally similar to that illustrated and described in the original Specification of the parent application. However, there is no separate compression spring acting upon the lever *A* pivoted at *B*. Furthermore, the arrangement is such that the rod *C* is stressed in compression under the influence of the bowed leaf spring *D*, suitably a single leaf, which acts between the abutment or hinge point *E* on the lever *A*, and the fixed abutment or hinge point *F* and guides the chain *G*. For this purpose, the rod *C*, adjustably but fixedly anchored at its lower end in the bracket *H*, is acted upon axially at its upper end by an adjustable lock screw *K* in the lever *A*. The screw engages the rod with a rounded or more or less pointed end. Since the leaf spring seeks to return to a straight condition, it exerts a clockwise movement on the lever *A*, so that the rod *C* is stressed in compression. The manner of operation of the device is essentially the same as that described in the parent application. Whereas the distance *OP* between the axes of the driving and driven sprocket wheels and the distance *OB* will increase due to thermal expansion, the distance *OK* is designed to remain unchanged or at least to vary differentially. Consequently the abutment *E* is caused to rise so that the leaf spring *D* can stretch or straighten itself and thus continue to afford proper guidance and support for the chain without the loading of or the tension in the chain being materially changed.—*July* 9, 1958.



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British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, Park Street, London, W.1.

WIRE ROPE FITTINGS

No. 461 : "Bordeaux Connections." Price 5s. This twenty-page standard specifies the dimensions, materials and inspection, testing and certification requirements for the fittings ("Bordeaux connections") used for attaching wire rope to short link chain. The safe working load of the Bordeaux connections is to be between 1 ton 8 cwt and 10 tons 10 cwt. The specified sizes of wire rope range from ½in to 1¼in diameter. One of the standard's three appendices deals with "splicing a Bordeaux connection with a wire rope." There are fully annotated illustrations of a Bordeaux connection and a higher tensile steel grab shackle.

No. 462 : "Bull Dog Grips." Price 4s. 6d. This sixteen-page standard specifies materials and dimensions for the fittings ("bull dog grips") used to secure the end of wire rope as an alternative to splicing or socketing (e.g. in the absence of skilled labour or other facilities for such work). The range of nominal sizes is ⅜in to 2½in. An appendix to the standard deals with a method of applying bull dog grips to wire rope. There are illustrations showing the correct and the incorrect method.

No. 463 : "Drop-Forged Sockets for Wire Ropes for Engineering Purposes." Price 5s. This eighteen-page standard specifies materials and dimensions for drop-forged sockets, of the open or closed types, for wire ropes of ⅜in to 1¾in diameter. "They are also suitable," states the Foreword, "for use on colliery haulages, where they are used with a coned, tailed strand." One of the standard's two appendices gives a recommended method of hot white metal socketing. The dimensional tables for open type sockets and closed type sockets are shown in conjunction with annotated diagrams.

No. 464 : "Thimbles for Wire Ropes." Price 5s. This eighteen-page standard specifies materials and dimensions for thimbles for wire ropes of nominal sizes from ⅜in to 2½in. The types of thimble specified are : ordinary, ⅜in to 2½in ; reeving, ½in to 1½in ; solid, ⅜in to 2½in.

An appendix to the standard gives a recommended method of making a wire rope thimble splice. Dimensional tables for each type of thimble are shown in conjunction with fully annotated diagrams.

No. 716 : "Rigging Screws and Stretching Screws for General Engineering Purposes." Price 7s. 6d. This thirty-page standard specifies materials, components, dimensions, finishing requirements and tests for rigging screws and stretching screws of nominal size ½in to 2½in and ¼in to 2in respectively. All dimensional tables are presented in conjunction with fully annotated diagrams. An appendix to the publication provides the form of words for a certificate of test.

No. 1290 : "Wire Rope Slings and Sling Legs." Price 10s. This fifty-one page standard specifies dimensions, construction, loading and marking and test requirements for one, two, three and four-leg slings with legs of the following types :—Single part sliced ; double part sliced endless, and double part grommet. The slings are for use with wire ropes of ⅜in to 1¾in nominal diameter. The first and second of the standard's three appendices provide a form of warranty and information on safe working loads respectively. The third appendix provides appropriate tables and figures from relevant British Standards. There are ten full-page diagrams.

KEYS AND KEYWAYS

No. 46 : Part I. 1958. Price 7s. 6d. A revised edition of this specification has been issued as a result of requests for larger manufacturing tolerances. The various types of keys and keyways now have, as far as possible, consistent dimensions and tolerances, thus enabling a standard range of cutters to be used for machining the various types of keyway. It is pointed out, however, that the increased tolerances recommended may inevitably entail more fitting of keys into keyways than was envisaged in the 1953 edition.

The tolerances on the width and depth of rectangular and square plain and gib-head keys have been increased ; and keys of ⅛in size have been eliminated. Details of tangential keys have again been included, the section dealing with marine tailshaft keys has been re-written ; and recommendations on the preferred lengths of keys have been revised and brought into line with current practice.

CONTINUOUSLY HOT-DIPPED GALVANISED PLAIN STEEL SHEET AND COIL

No. 2989 : 1958. Price 3s. 6d. This new standard specifies six classes of galvanised plain steel sheet and coil thinner than 0·118in with a maximum width of 48in, and coated by the continuously hot-dipped galvanising process from coil produced on a wide strip mill. The six classes are divided into two groups. For one group the specified weights of zinc coating vary from 2·5 oz per square foot to 1·5 oz per square foot ; for the second group the zinc coating is lighter, but the product has additional fabricating properties. Steel sheet and coil in the first group are subject only to the test for coating adherence. This group is intended to provide a high degree of protection against corrosion of the parent metal. In general the product will be used as flat sheets, although it can be bent to a limited extent. The first class in the second group is intended, from the point of view of coating weight and bending properties, to meet requirements between those suitable for sheets normally used as flat sheets and those for material for severe bending. The remaining two classes in this second group are intended to provide for severe bending in subsequent fabrication. The standard specifies dimensional tolerances on sheet and coil, as well as detailed tests for the determination of coating weight and coating adherence.

Launches and Trial Trips

LA COLINA, ore carrier ; built by the Chantiers Reunis Loire-Normandie (Grand Quevilly) for Buries Markes, Ltd.; length between perpendiculars 410ft 1¾in, breadth moulded 57ft, depth to upper deck 32ft 3in, draught loaded 25ft.; two main ore holds, one cargo hold ; speed with half load 13·5 knots, service speed 12 knots ; two Deutz Mark RBV8M366 diesel engines, each of 2000 h.p. at 275 r.p.m., drive single shaft at 100 r.p.m. through Vulcan reduction gears. Trial, June.

FORT NIAGARA, banana carrier ; built by the Chantiers et Ateliers de Provence for the Compagnie Générale Transatlantique ; length overall 373ft 6in, breadth moulded 61ft 8in, depth 35ft 4in, draught loaded 21ft 5in, deadweight 3200 tons ; twelve passengers ; fruit capacity 1750 tons ; Provence-Doxford turbo-charged Mark 60S.B.6 oil engine, 6000 b.h.p., service speed 17 knots. Trial, June.

CLAN MACIVER, cargo liner ; built by the Greenock Dockyard Company, Ltd., for Clan Line Steamers, Ltd.; length between perpendiculars 455ft, breadth moulded 61ft 6in, depth moulded to upper deck 38ft 7½in, deadweight 10,000 tons on 26ft 4in mean draught, service speed 13½ knots ; five holds, bale capacity 589,000 cubic feet, two 80-ton, two 15-ton, six 7-ton and ten 5-ton derricks, electric deck machinery ; three 185kW diesel-driven generators ; Barclay Curle-Doxford opposed-piston oil engine, five cylinders, 670mm diameter by 2320mm combined stroke, 5000 b.h.p. at 110/113 r.p.m. Launch, June 23.

ENUGU PALM, cargo liner ; built at the Neptune Works of Swan, Hunter and Wigham Richardson, Ltd., for the Palm Line, Ltd.; length between perpendiculars 425ft, breadth moulded 60ft, depth moulded to shelter deck 35ft 3in, deadweight 7930 tons on 23ft 5in draught ; five holds, one 40-ton, four 15-ton, two 10-ton and ten 5-ton derricks, sixteen electric winches ; three 250kW diesel-driven generators ; Swan, Hunter-Doxford diaphragm oil engine, four cylinders, 670mm diameter by 2320mm combined stroke, 4500 b.h.p. at 118 r.p.m. Trial, June 24.

STREAMBANK, cargo ship ; built by William Doxford and Sons (Shipbuilders), Ltd., for The Bank Line, Ltd.; length between perpendiculars 450ft, breadth moulded 62ft, depth moulded to upper deck 38ft 6in, deadweight 12,120 tons on closed shelter deck draught ; five hatches, one 25-ton, four 10-ton and ten 5-ton derricks ; Doxford opposed piston oil engine, four cylinders, 700mm diameter by 2320mm combined stroke, 4800 b.h.p. Launch, June 30.

CITY OF HEREFORD, open shelter deck cargo liner ; built by the Caledon Shipbuilding and Engineering Company, Ltd., for Ellerman Lines, Ltd.; length overall 434ft, breadth moulded 59ft, depth moulded 36ft 9in to shelter deck, 7400 tons deadweight on 24ft 6in draught, service speed 14½ knots ; four cargo holds, MacGregor hatch covers, ten 7/10-ton derricks, electric winches ; three 180kW diesel-driven generators ; Clark-Sulzer single-acting, two-stroke diesel engine, eight cylinders, 5040 b.h.p. at 121 r.p.m. Launch, June 30.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

INSTITUTE OF ROAD TRANSPORT ENGINEERS

Thurs., Aug. 21.—METROPOLITAN AREA : Visit to L.T.E. Works, Aldenham, Middlesex.

Advanced Engineering Courses

Operational Research Course. THE UNIVERSITY OF BIRMINGHAM, INSTITUTE FOR ENGINEERING PRODUCTION, "Southfield," 16, Norfolk Road, Edgbaston, Birmingham, 15. Residential course, Monday, September 15, to Friday, September 26. Inquiries should be addressed to the Director of the Institute for Engineering Production. Residential fee 50 guineas.

Post-Graduate Courses in Electrical Machines. IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY, ELECTRICAL ENGINEERING DEPARTMENT, CITY AND GUILDS COLLEGE, Exhibition Road, London, S.W.7. Two vacation courses. The first from Monday, September 1, to Friday, September 19, on "Limiting Physical Phenomena in Electrical Machines." The second, from Monday, September 22, to Saturday, September 27, on "Generalised Theory of Electrical Machines." Further particulars may be obtained from the Deputy Registrar, City and Guilds College, London, S.W.7.

Production Planning and Control. THE UNIVERSITY OF BIRMINGHAM, INSTITUTE FOR ENGINEERING PRODUCTION, "Southfield," 16, Norfolk Road, Edgbaston, Birmingham, 15. Residential executive course from Monday, September 1, to Friday, September 12. Inquiries should be addressed to the Director of the Institute for Engineering Production. Residential fee 50 guineas, non-residential 40 guineas.

Principles and Practice of Non-Destructive Testing. THE MANCHESTER COLLEGE OF SCIENCE AND TECHNOLOGY, Manchester, 1. Summer school intended to benefit senior and chief inspectors, from Monday, September 8, to Friday, September 12. This summer school has been sponsored by the British National Committee for Non-Destructive Testing and is being organised by the Manchester College of Science and Technology, the Manchester Association of Engineers, and the Institution of Engineering Inspection. The total cost of the course is expected to be approximately £18. Inquiries should be addressed to the Registrar, The Manchester College of Science and Technology.

Work Study. BOROUGH POLYTECHNIC, MECHANICAL ENGINEERING DEPARTMENT, Borough Road, London, S.E.1. The course is intended primarily for students who have already qualified for Parts I and II of the Institution of Production Engineers, and who wish to prepare for the work study examinations in Part III under the existing regulations for 1958/59. Enrolment dates are September 15, 16 and 17, from 5.30 p.m. to 8 p.m. The fee for the complete course is £2.

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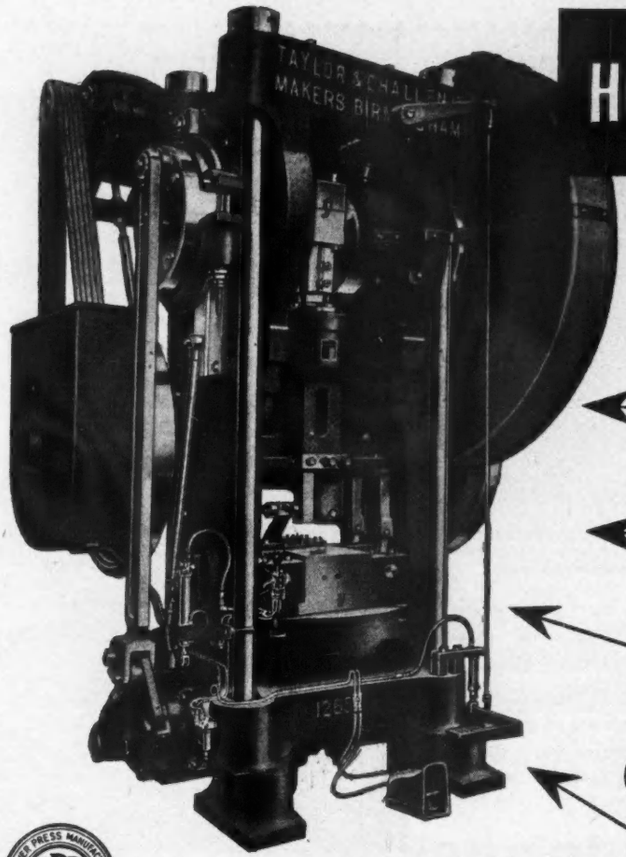

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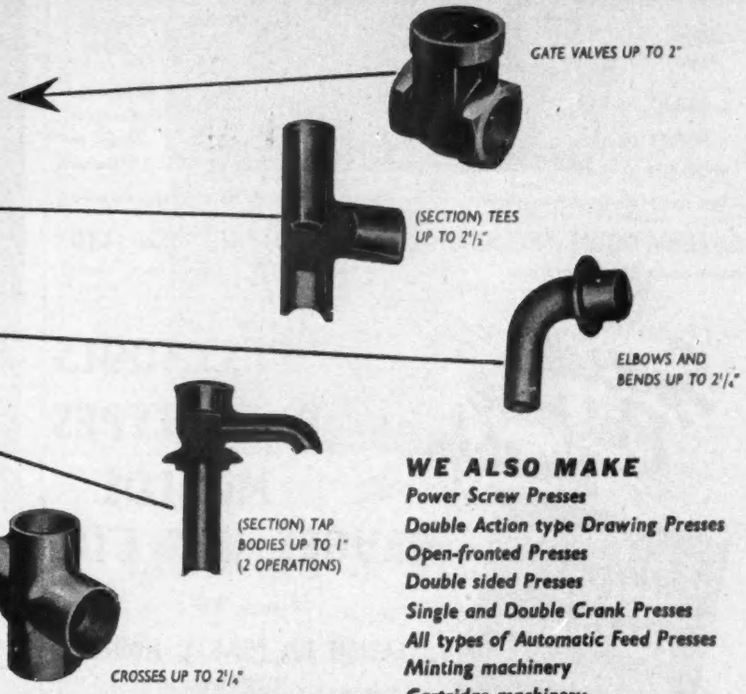

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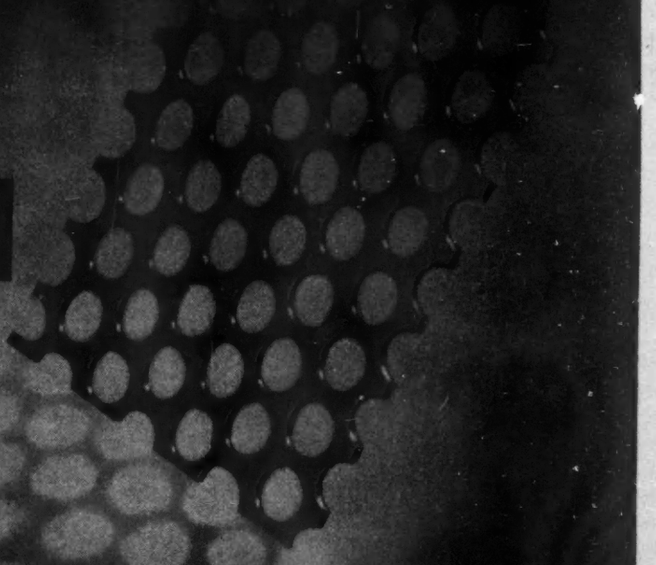

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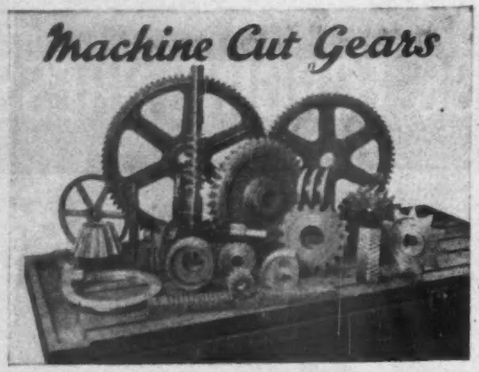

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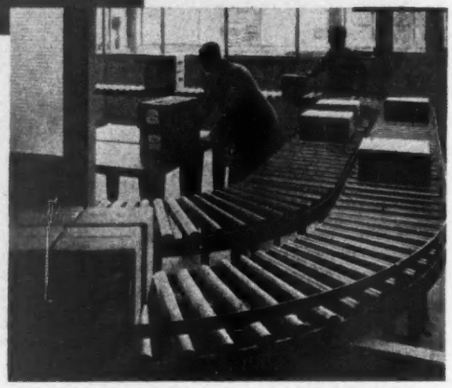

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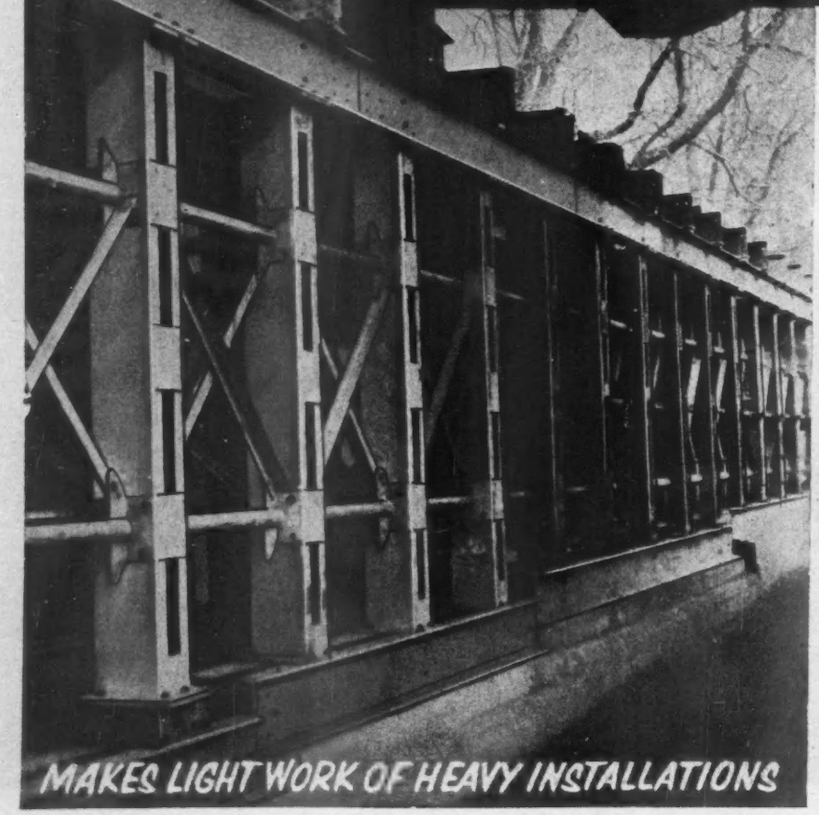

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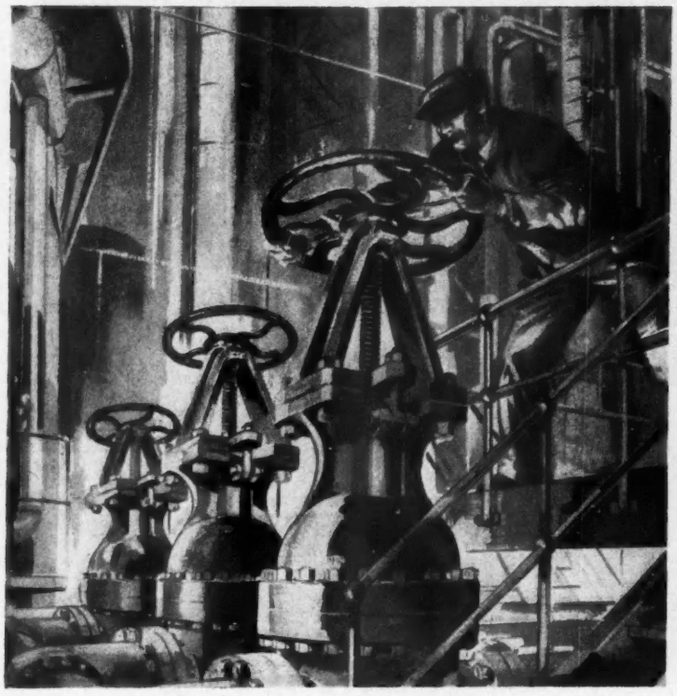

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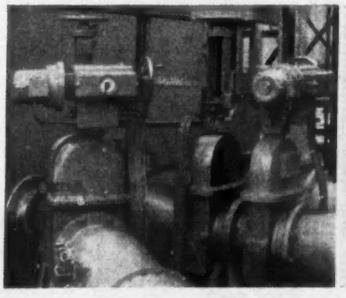
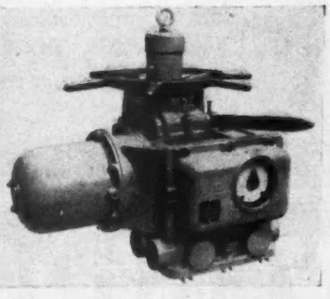


This photograph of air supply lines to reactor at A.E.R.E., Harwell, shows 12" Cort valves fitted with Rotork 100 A II actuators.



A Rotork 50AS actuator, Buxton Certified FLP Groups II and III, as used by Shell, B.P., Esso, Kuwait and Standard, for operating gate and conduit valves.

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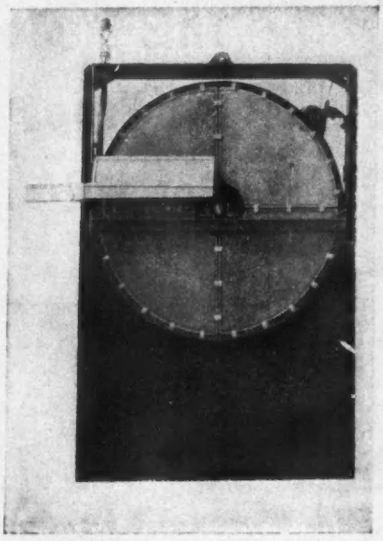

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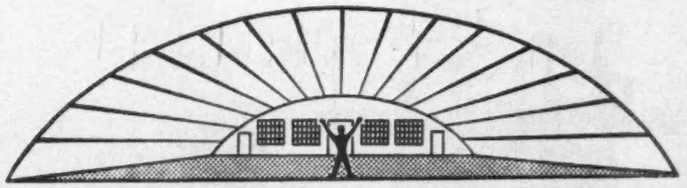

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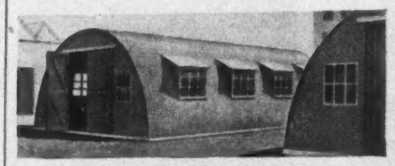

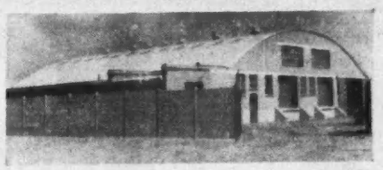

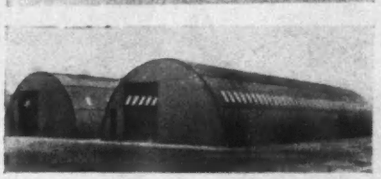

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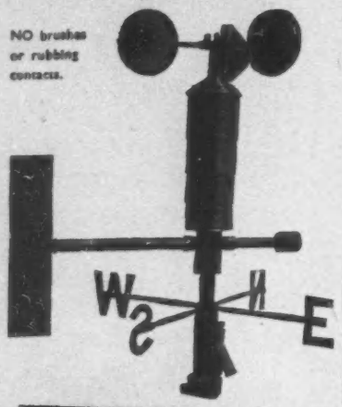

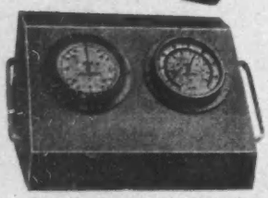

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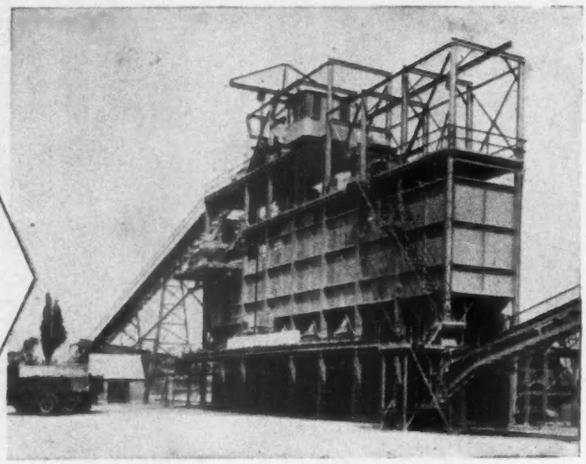

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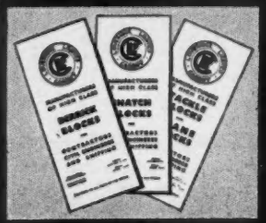

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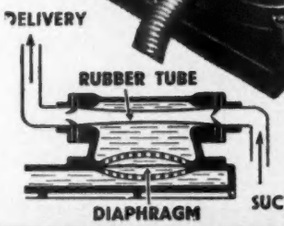

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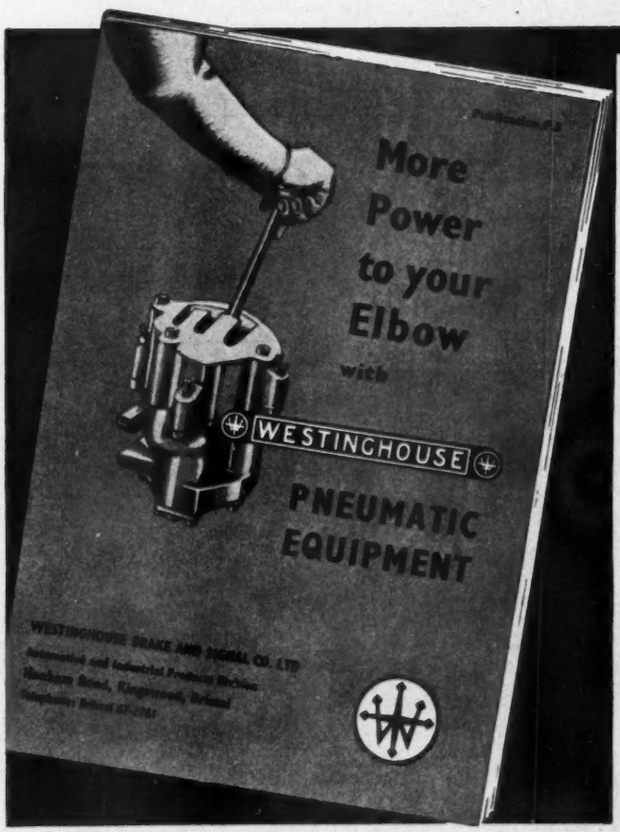

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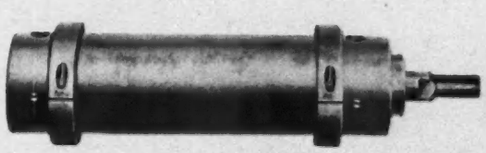

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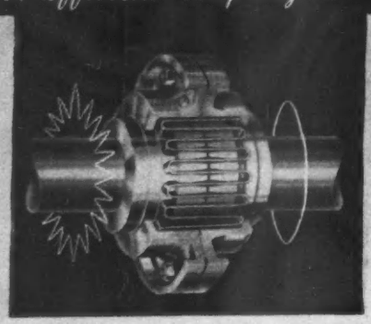

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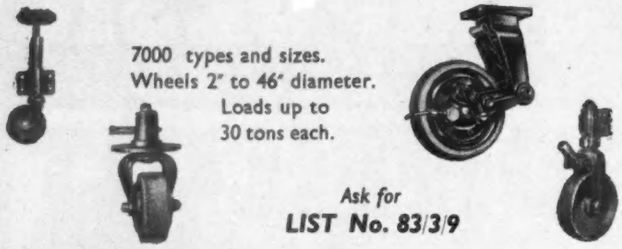

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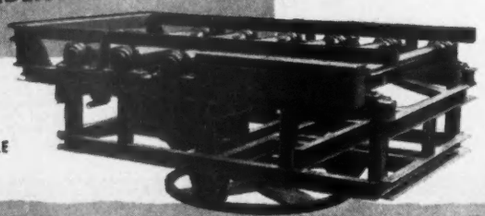

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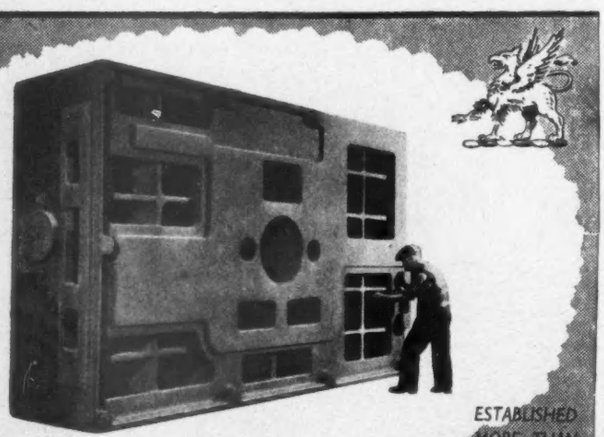

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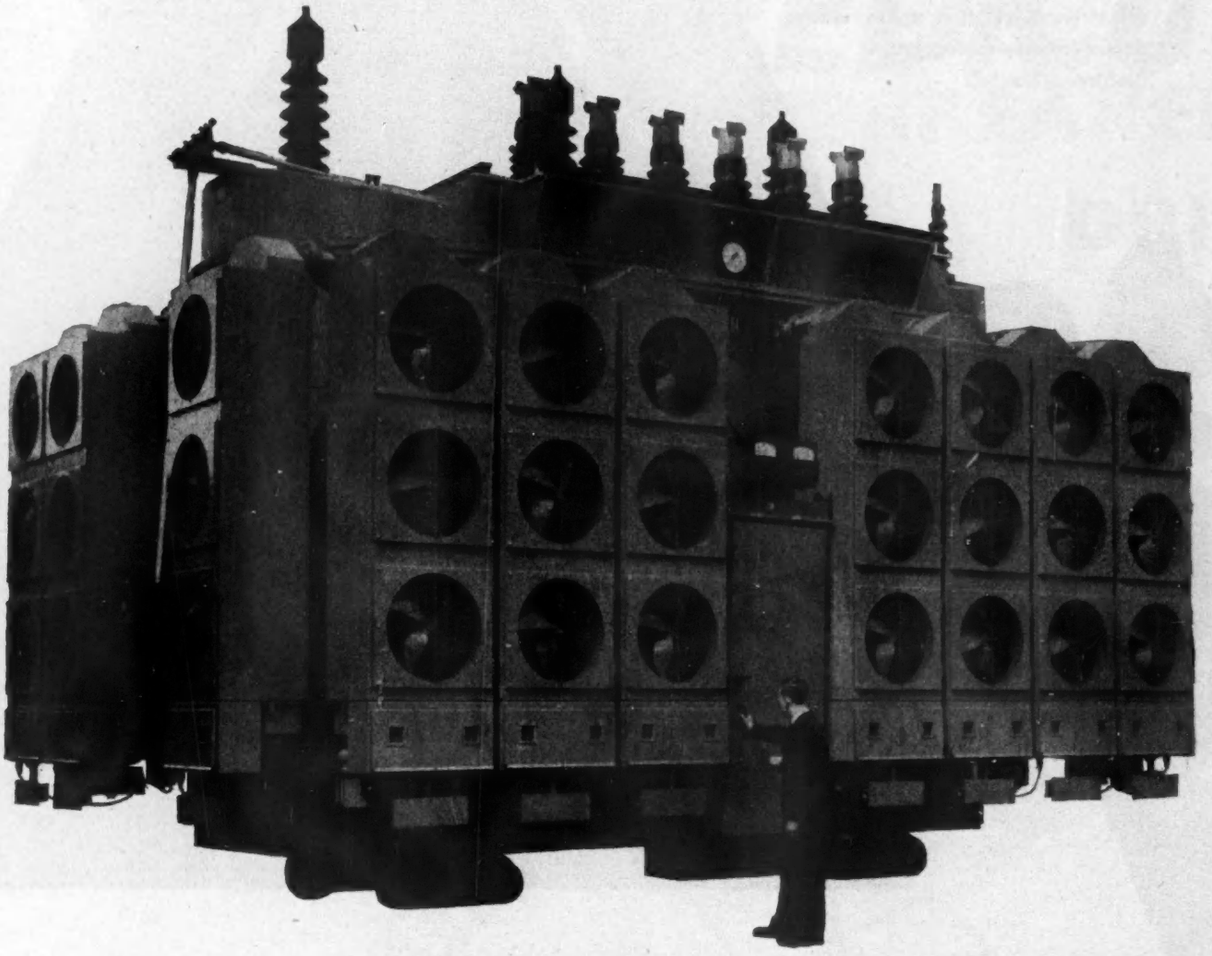

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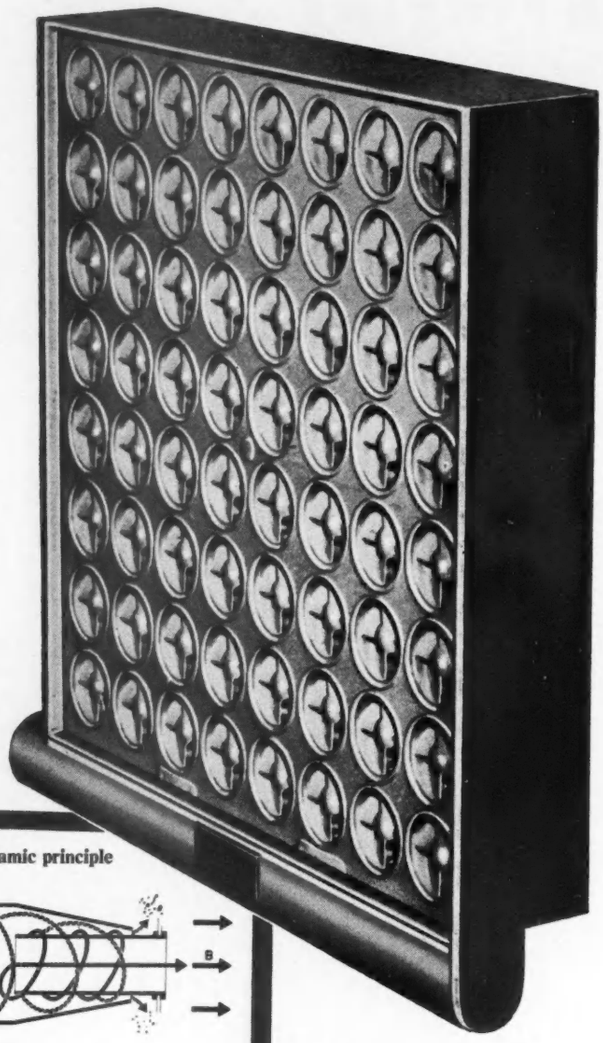
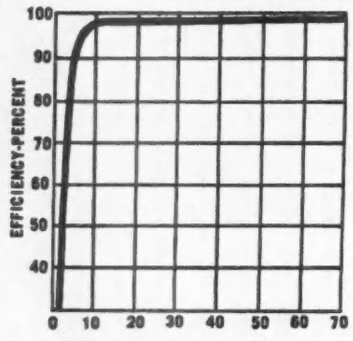
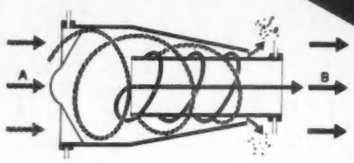
Reciprocating engines and air compressors attain their higher efficiencies through the use of smaller working clearances and relatively high speeds of revolution. Clean air, essential to such high performance machines, is reliably obtained at low cost through Rotonamic filtration.



Graph of Rotonamic efficiency percentage plotted against dust particle size



The Rotonamic principle



Air entering a Rotonamic panel at A is centrifuged at speed by the helical vanes. 10% of the air conveys dust to the bleed-off tube at the base of the panel. The remaining 90%, cleaned and filtered, reverses direction, enters the tube and exits at point B.

The illustration shows a Rotonamic panel comprising multiple static vanes which impart a whirling motion to the air entering the panel. The dust is centrifuged from the air and is bled off to atmosphere or dust bin.

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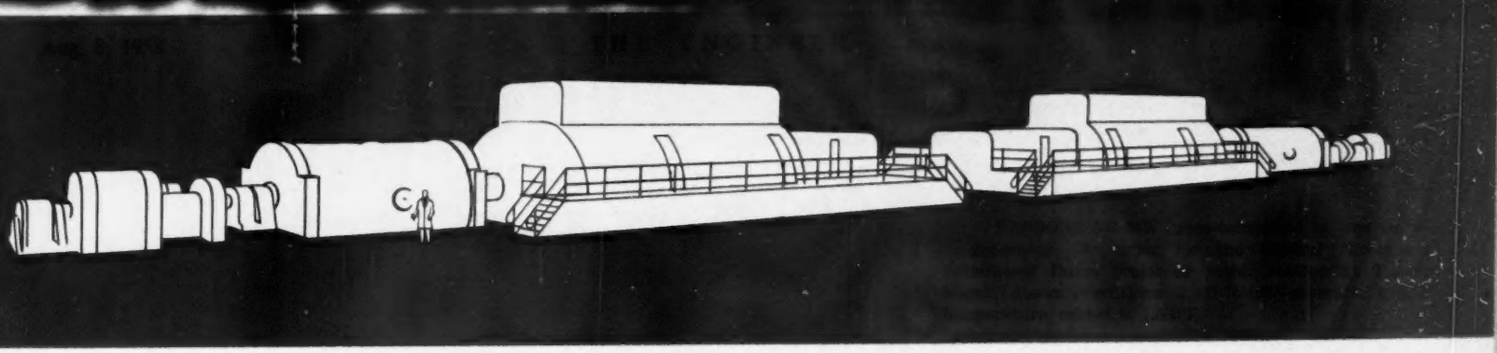
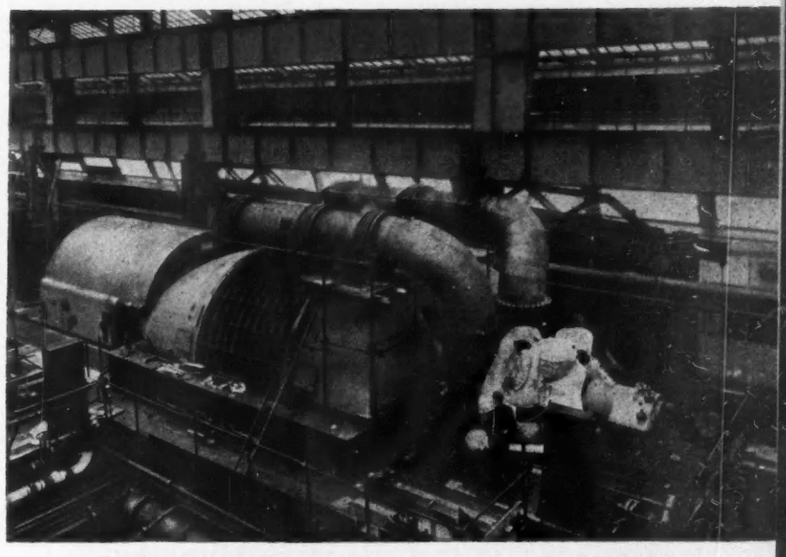
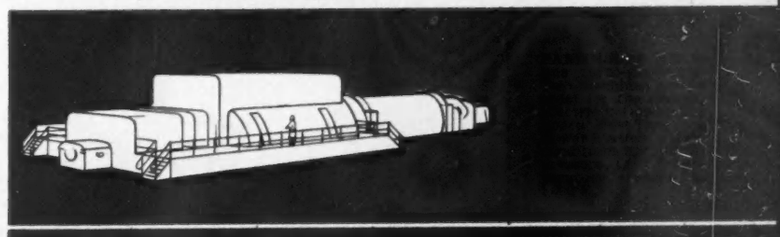


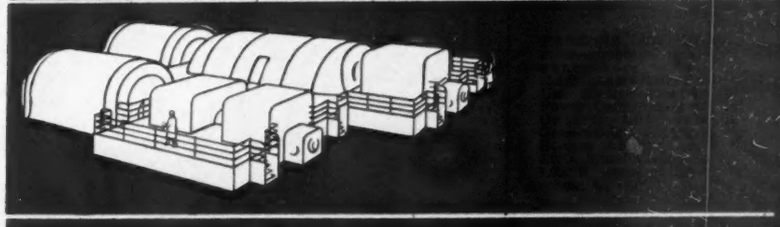
Increasing power output

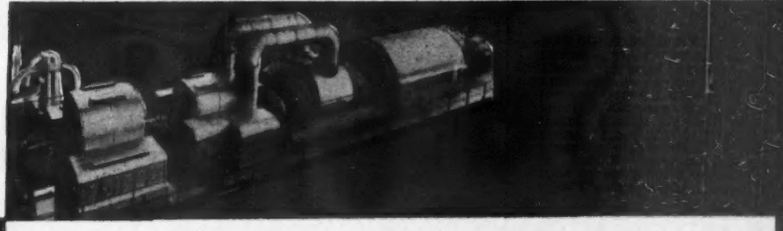
A significant development in the design of steam turbo-generators for power stations is the increase in the power output of individual machines. This is evident in the range of large turbo-generators now under construction at Heaton Works.



PARSONS 200 MW cross-compound turbo-generator (View of low pressure line only). Four of these machines are under construction for the Hydro Electric Power Commission of Ontario, Richard L. Hearn Generating Station. Steam conditions: 1,800 lb/ins² pressure, 1,000°F temperature, reheat to 1,000°F.







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Stepless speed variation over a 9 to 1 output speed range (1/3 to 3 times the input speed).

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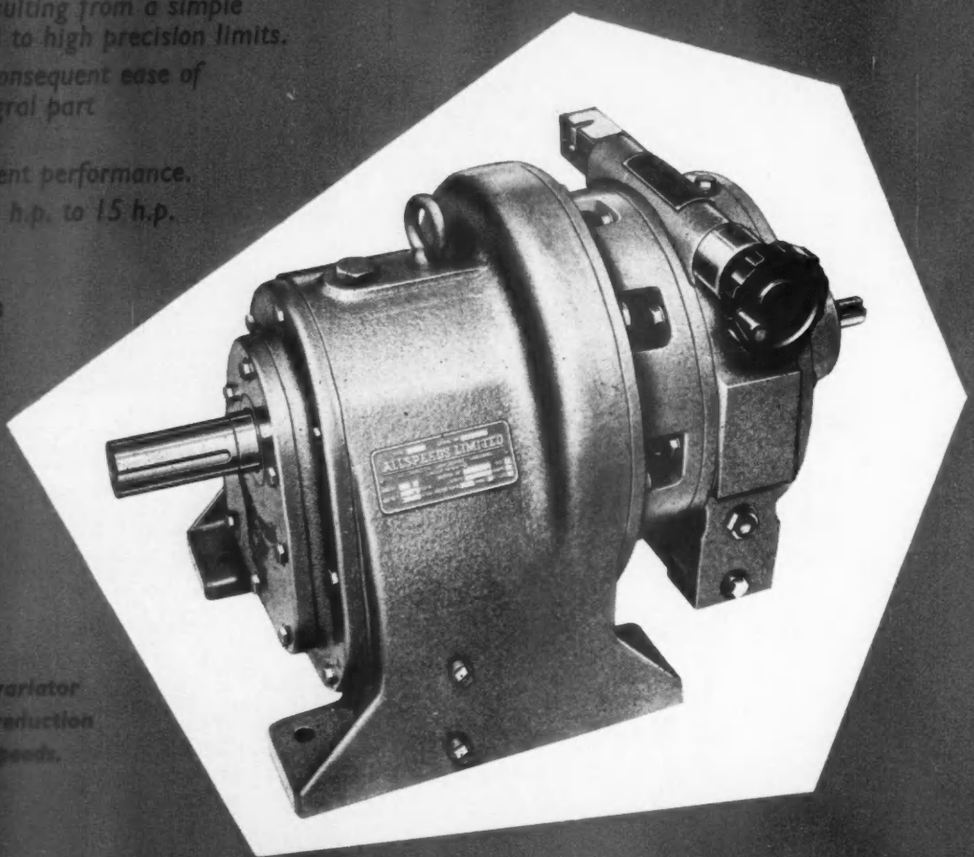
Kopp VARIABLE SPEED GEAR



Illustrated is a 2 h.p. variator with flange mounted reduction gear for low output speeds.

Allspeeds Limited

Oakenshaw Works, Clayton-le-Moors, Accrington, Lancs. Telephone: Accrington 5441 (4 lines)

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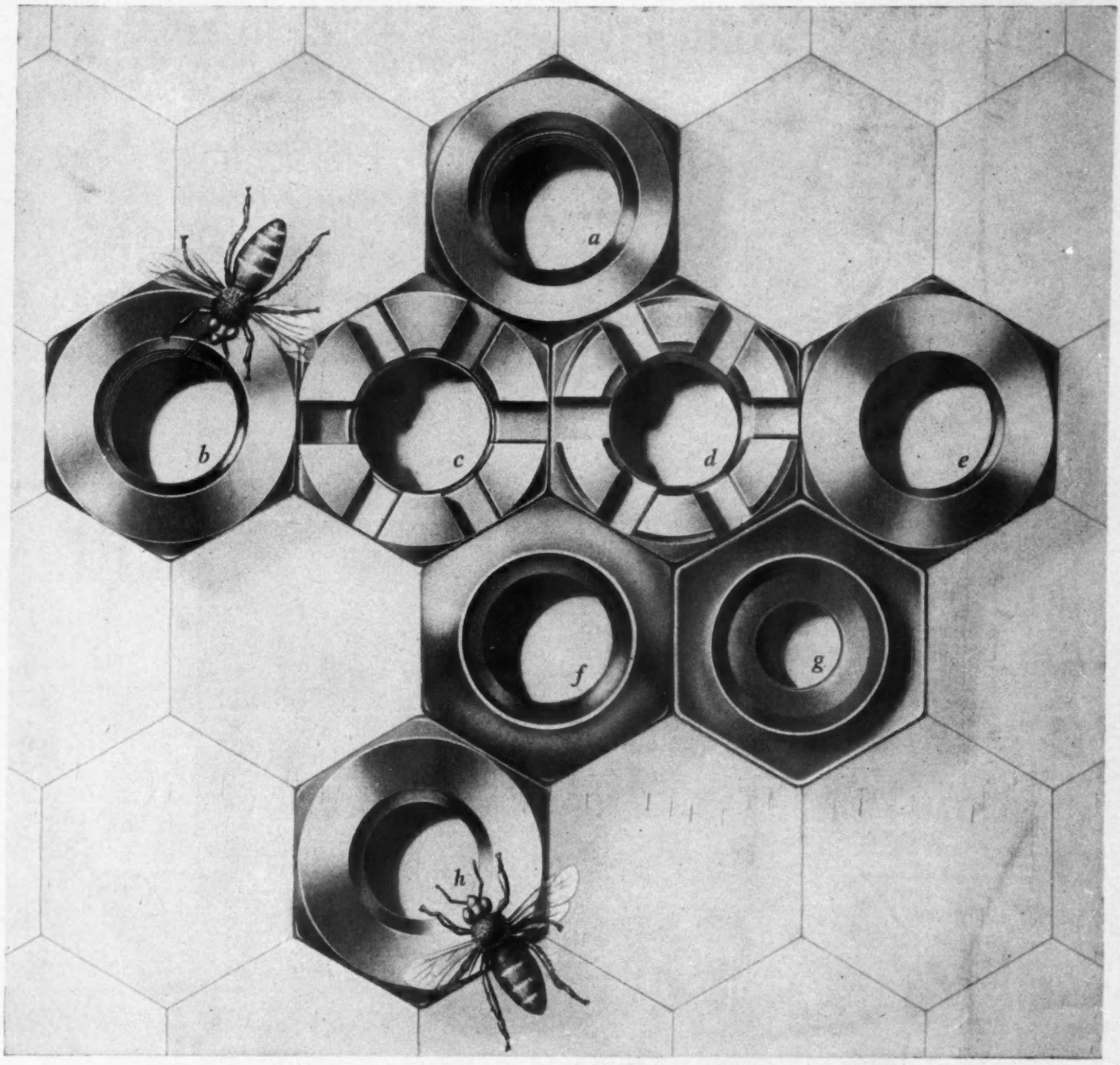

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Simmonds, the self-locking nut specialists, also make standard nuts faster than you can use them—bar turned and cold formed, in a wide range of sizes, steels and finishes. There are so many you can always get *exactly* the nut you want. If you need a special nut or turned part for a special job you can get that too. Just contact Simmonds.

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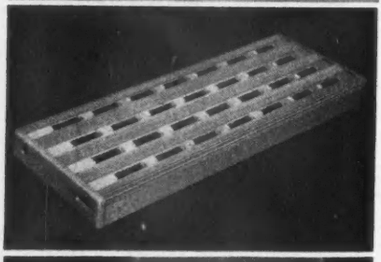

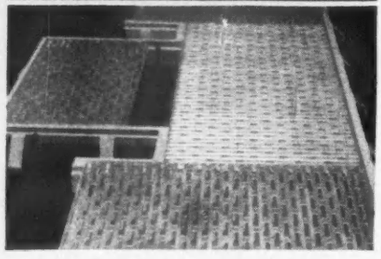

Down-to-earth industrialists have been quick to install Alaflor extruded aluminium flooring. It's outstanding economy and safety cannot be ignored.

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Put Alaflor underfoot for saving and safety's sake.
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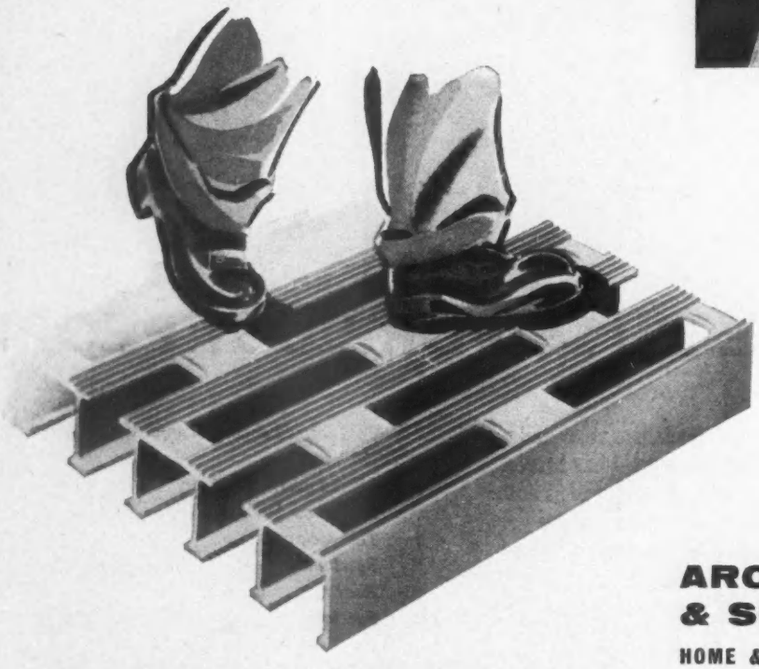

or feet on ALAFLOR

NOTE: Alaflor is manufactured in 6in. widths and extruded to a maximum length of 24ft. Grating depths from ¾in to 2in. Available in two types (a) Rectangular (illustrated), size of punch 3in. × ⅜in. (b) Square, size of punch ⅜in.

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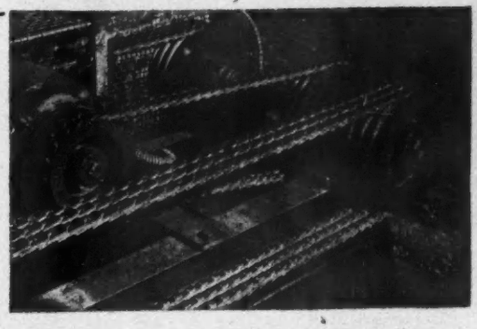

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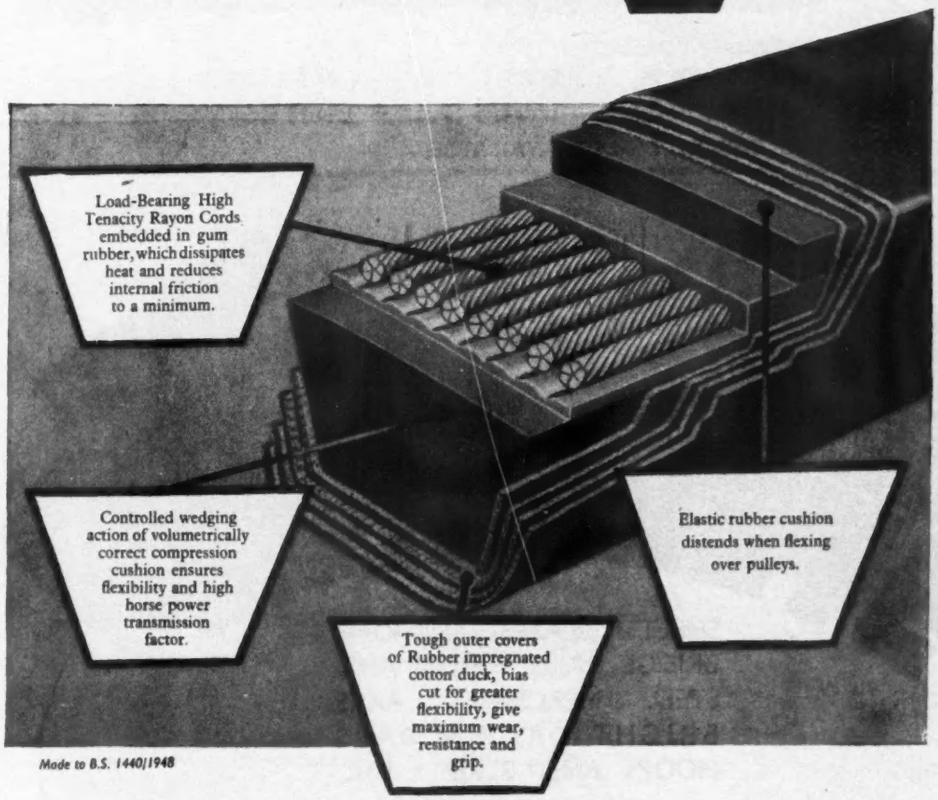
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Elastic rubber cushion distends when flexing over pulleys.
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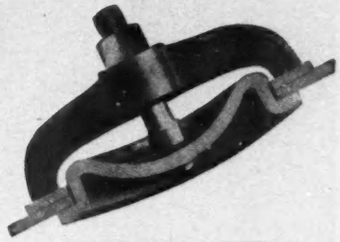

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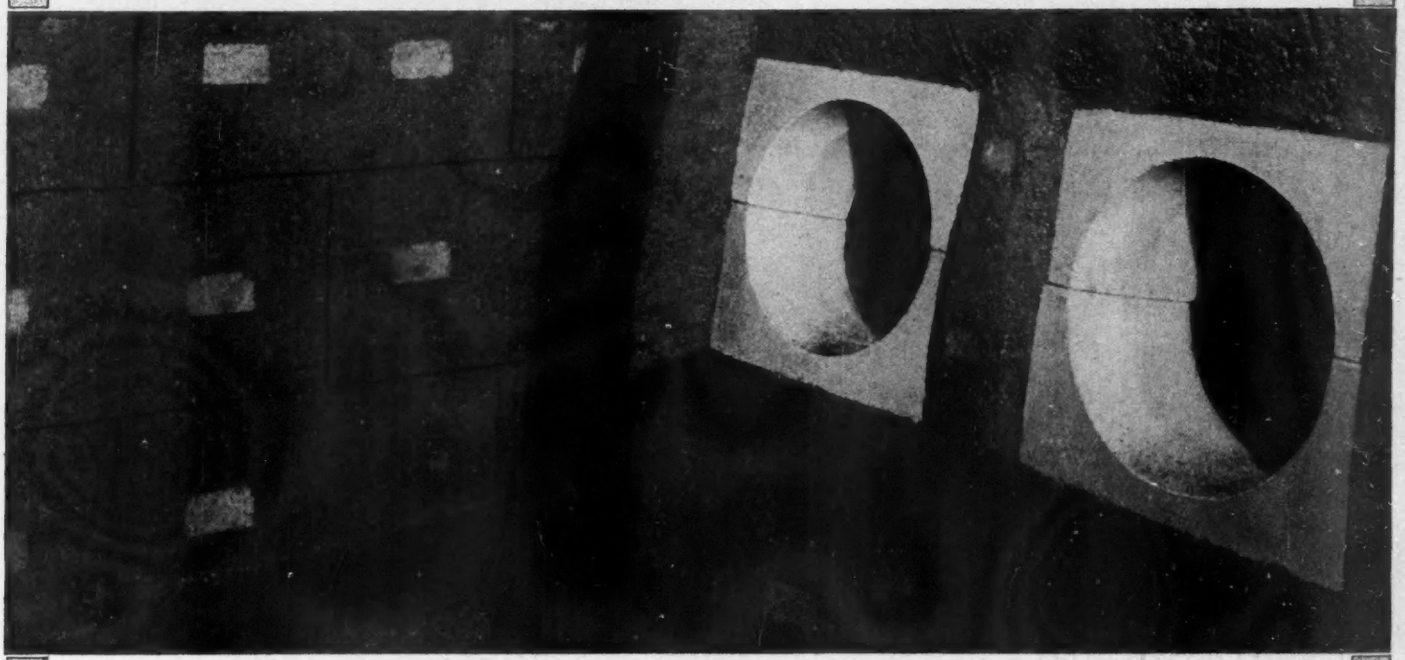

Front and side walls of a Queen Mary boiler in Tri-Mor High Temperature Mouldable, with MR 60 anchors. Burner quarls in Tri-Mor High Temperature Castable.

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TRI-MOR *Standard Castable*
A medium texture refractory having negligible shrinkage up to 1,350°C. Suitable for casting special shapes or for monolithic structures. Limiting service temperature 1,350°C.

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A similar refractory to Tri-Mor Standard Castable, but specially developed to have very high mechanical strength over the lower temperature range. Maximum service temperature 1,250°C.

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Suitable for face temperatures up to 1,600°C; has an extremely high resistance to thermal shock; used for cast in situ monolithic structures and for pre-cast refractory shapes; can be applied with a cement gun.

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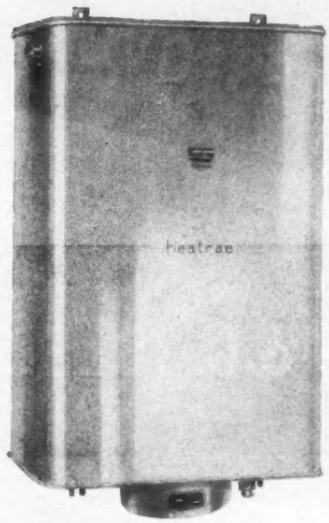

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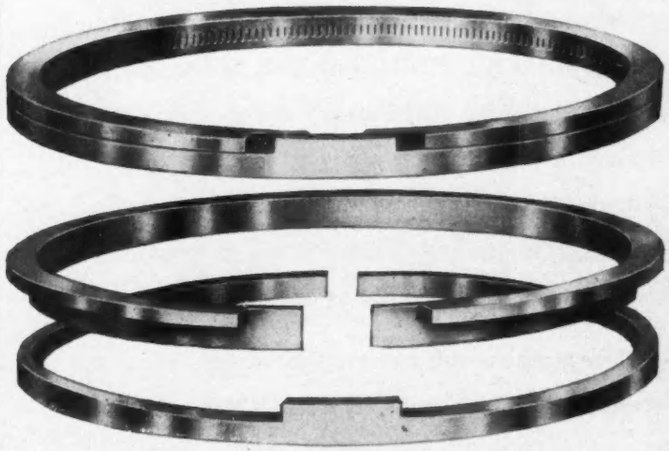

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Eliminate by-pass, Restore compression, Maintain full power, Function until bore of cylinder is worn by as much as 1%.

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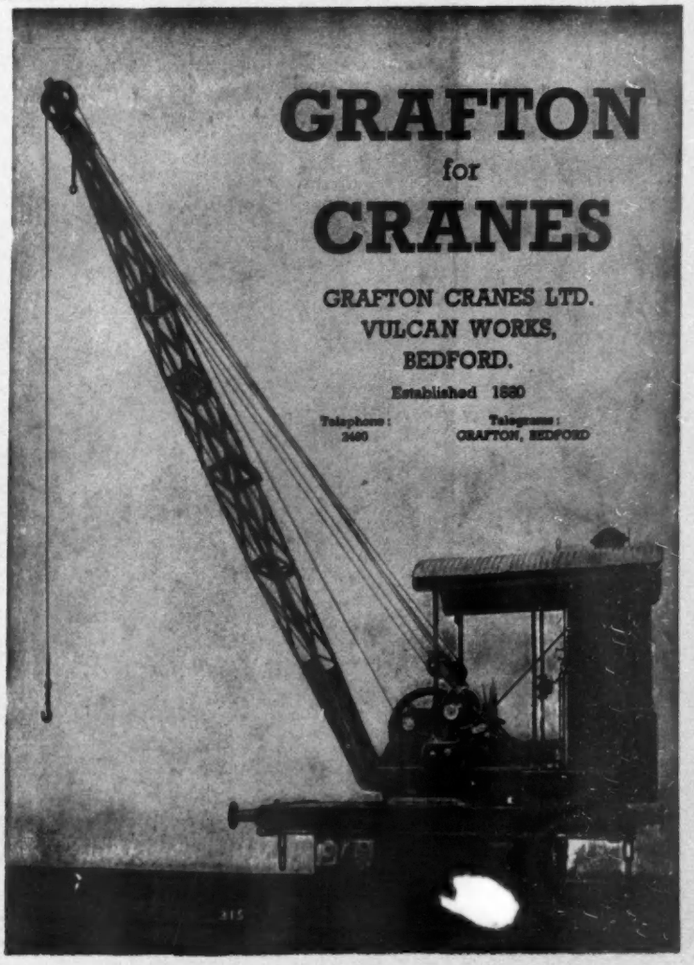

Idlers that run 20 hours out of every 24, and daily carry 6,000 tons of gold ore.

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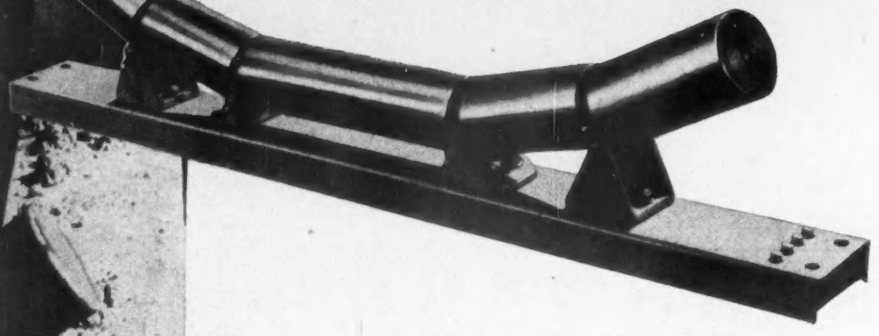

An idler for a 48-in. belt, with nipples for recharging the seals from one side.

Well sealed, M&C belt conveyor idlers are. They arrive with labyrinths full of soft grease, alert to keep the ball bearings specklessly free from grit and in perfect order. Without needing so much as a kind look, they give this protection throughout a good working life. And if they are refreshed occasionally by a shot from the gun, they keep it up many times as long, in fact as long as you like.

These perpetual seals are almost frictionless. They enable hard-working M&C idlers twenty years old to spin at a touch.

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New HIGH PRESSURE HOSES

Following the success of their hoses, Lockheed-Avery announce a new range, available with single and double wire braid, with a number of important features.

These hoses are backed by more than 20 years of experience in a wide range of industrial and aircraft hose applications, often in conjunction with other equipment made by the AP group.

The hoses are suitable for pressures ranging from 300-lbs. per sq. in. for 2" bore hose to 4050-lbs. per sq. in. for $\frac{1}{8}$" bore hose.

End-fittings are of steel, with hexagonal sleeves which expedite fitting, and are re-usable.

When desired, swaged-on end-fittings can be supplied for hoses up to $\frac{3}{8}$" bore.

90° elbows and 45° bends are available.

FOUR DIFFERENT LININGS

These new hoses types 77-99 have the advantage that they can be supplied with any one of these four linings:

NITRILE : NATURAL RUBBER : BUTYL : NEOPRENE

A list of compounds, with the lining recommended, can be supplied on request. The longest length of hose obtainable remains at approximately 30 ft. for hoses of $\frac{3}{8}$" bore and over, and approximately 15 ft. for hoses of $\frac{1}{4}$" and $\frac{1}{4}$" bore. Within these limits any desired length of hose assembly can be supplied.

FEATURES

Re-usable steel end fittings for strength and convenience

Hexagon sleeves for ease of assembly

Cadmium plated for corrosion resistance

Choice of four linings

Elbows and bends available

Wire braiding gives great safety.

Lockheed Avery

Regd. Trade Mark: Lockheed

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THREE STANDARD FITTINGS

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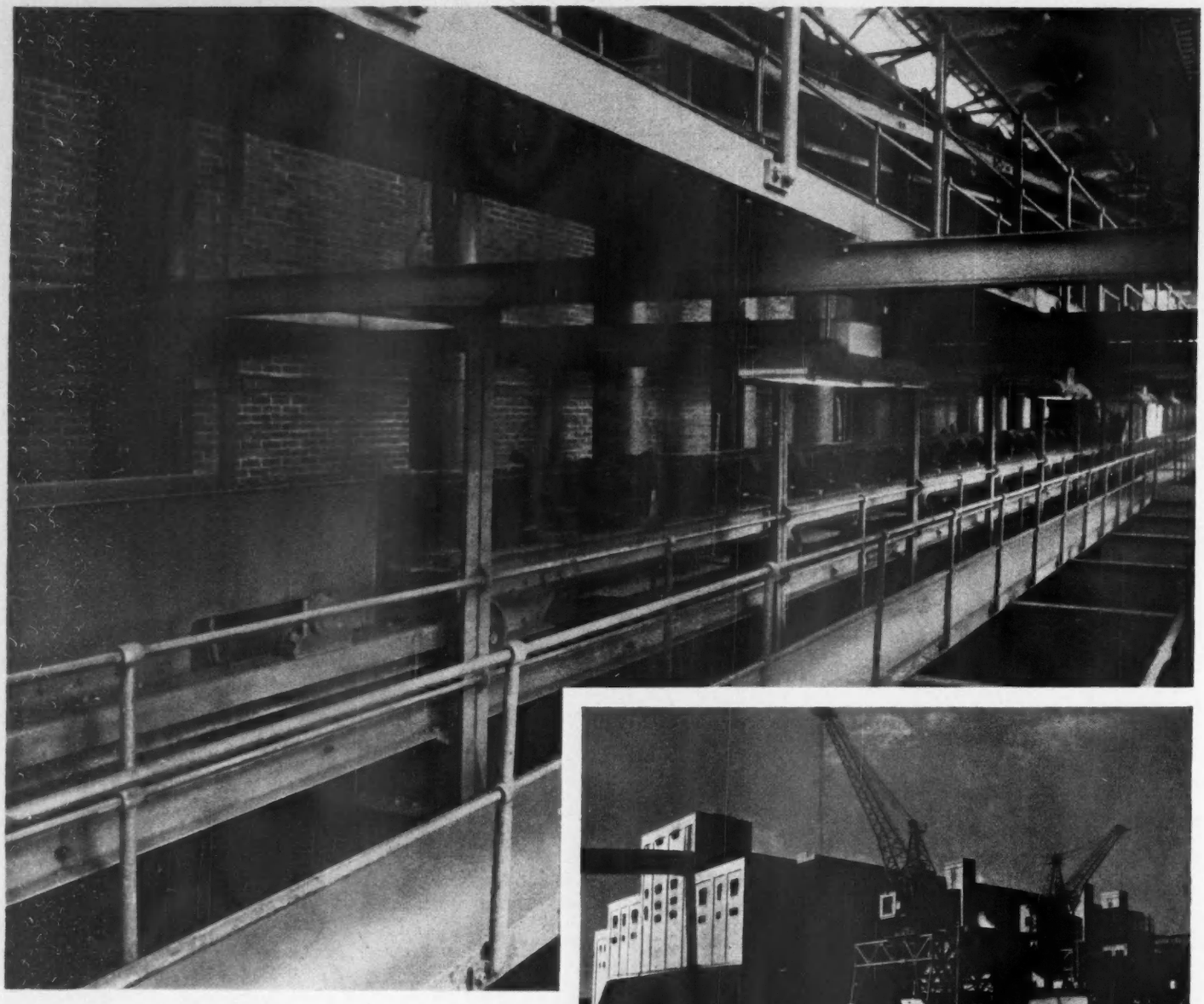
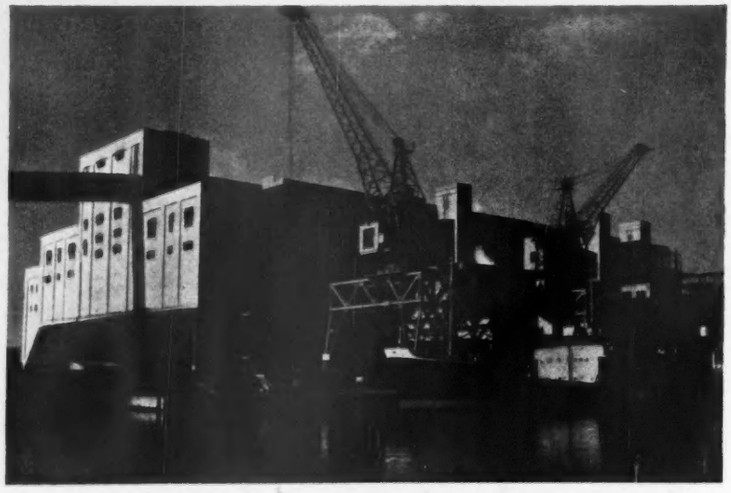
Coal & Coke handling equipment





SPENCER

SUPPLIED TO THE ORDER of WOODALL DUCKHAM CONSTRUCTION CO. LTD.

HANDLING PLANT AT THE PORTSLADE WORKS OF THE SOUTH EASTERN GAS BOARD

Spencer Coal and Coke handling equipment at these works consists of 50 Conveyors and six extensions to existing installations, varying in belt width from 24 in. to 48 in. and from 19 ft. to 389 ft. centres with capacities of 25 tons to 250 tons per hour. Our experience in the field of mechanical handling, gained over many years of service to industry, is at your disposal to assist in solving any handling problem which at present involves high time and labour costs in your organisation.

SPENCER (MELKSHAM) LIMITED · MELKSHAM · WILTSHIRE

Branch Offices: INGERSOLL HOUSE, 9, KINGSWAY, LONDON, W.C.2 Tel.: Covent Garden 1800

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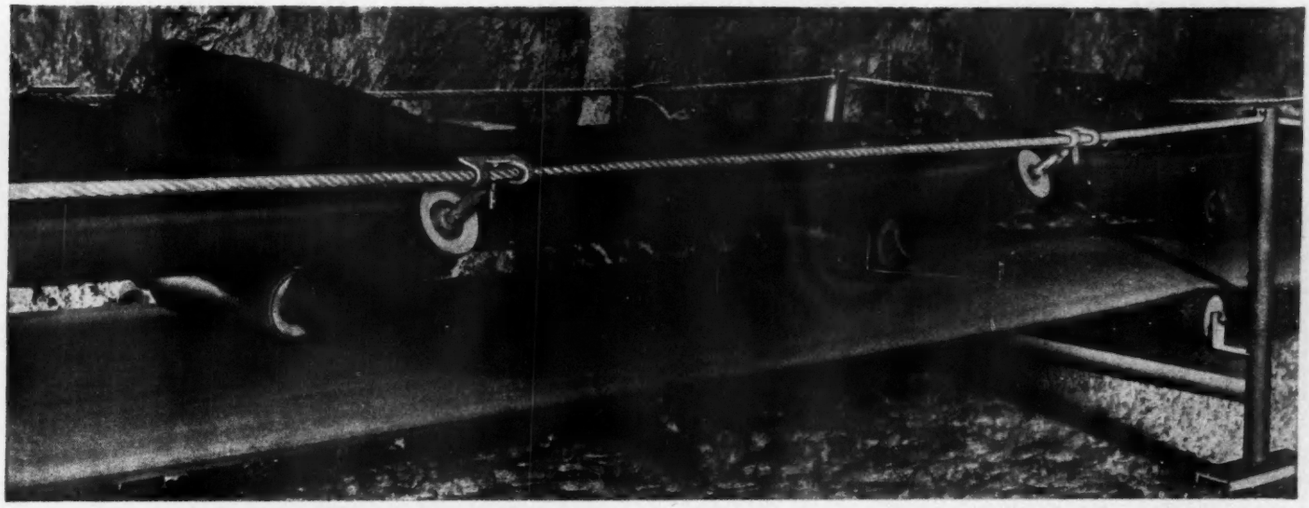
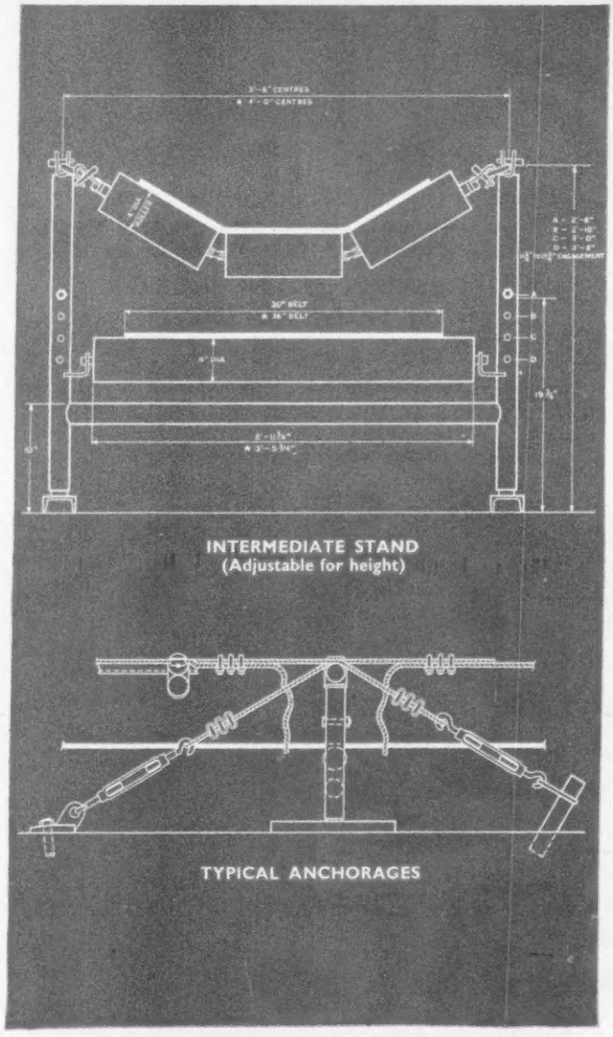




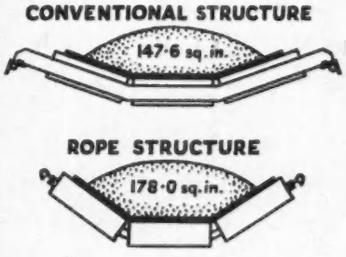
NEW RESILIENT

Distington - Goodman

BELT CONVEYOR STRUCTURE

(Patented)

- ***increases belt life***
- ***reduces installation costs***
- ***increases capacity***
- ***almost eliminates spillage***
- ***inexpensive***



Greater conveying capacity obtainable by increased troughing under load

The longitudinal members of this conveyor structure consist of $\frac{5}{8}$" dia. steel ropes in tension. The connections at the ends of each troughing idler shaft are hinged. These basic features provide a resilient conveyor which is easy to stack, transport and install — a conveyor in which impact damage to the belt as it passes over the idlers is greatly reduced. The belt is easy to train. The bottom belt is in full view and there need not be any concealed rubbing between belt and structure.

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DISTINGTON ENGINEERING COMPANY LIMITED
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THE
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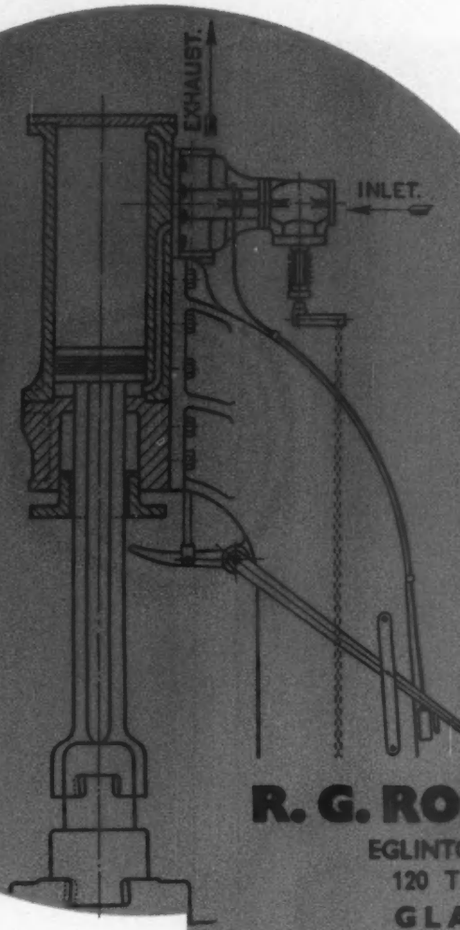
STEAM HAMMER

A phase of Railway Workshop activity abroad—showing "RIGBY'S PATENT" Hammer in operation.



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As Manufacturers of Austenitic Stainless Steel Wire, we can cover all your requirements to D T D, BS, AISI, etc., specifications.

These specifications include DTD 189, DTD 489, DTD 549, DTD 571, DTD 734, DTD 2002, etc.

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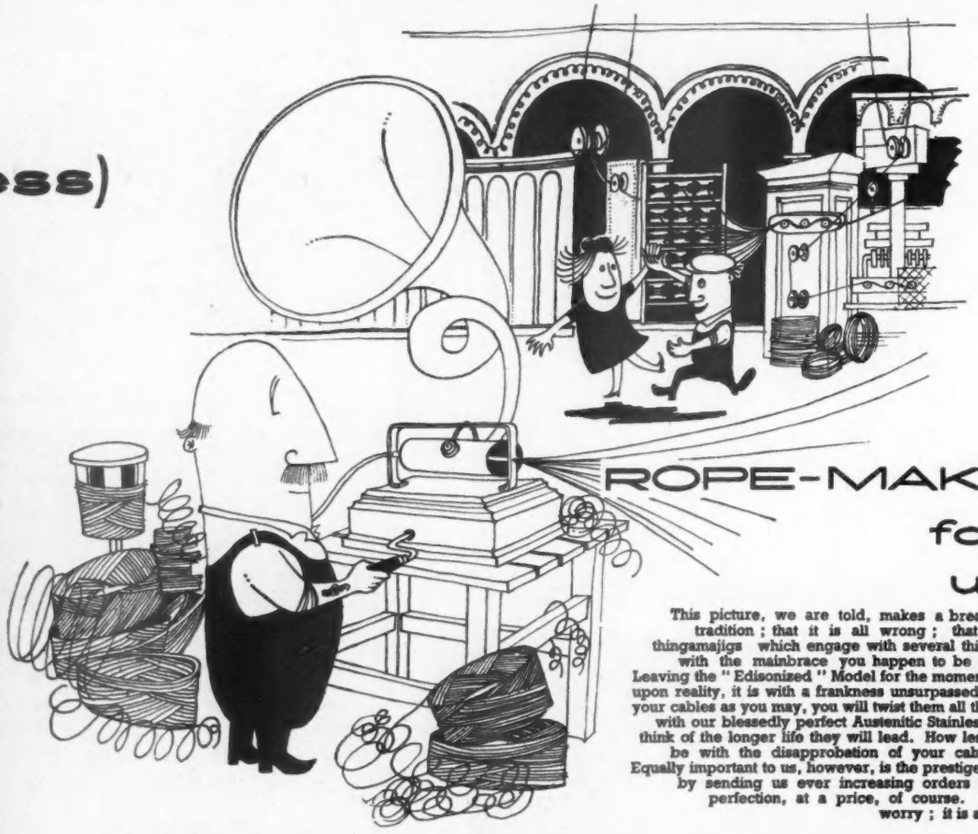
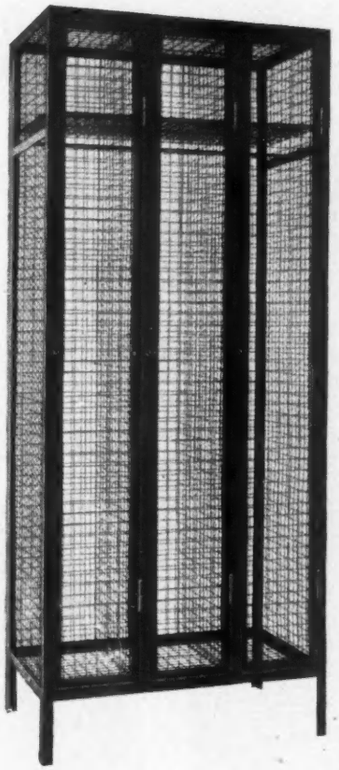


ROPE-MAKERS for the use of

This picture, we are told, makes a break with cablemaking tradition; that it is all wrong; that there are several thingamajigs which engage with several thingamabobs co-axial with the mainbrace you happen to be splicing at the time. Leaving the "Edisonized" Model for the moment, and concentrating upon reality, it is with a frankness unsurpassed that we say "Twist your cables as you may, you will twist them all the better, and faster, with our blessedly perfect Austenitic Stainless Steel Wire." And think of the longer life they will lead. How less bothered you will be with the disapprobation of your cable slinging friends. Equally important to us, however, is the prestige you confer upon us by sending us ever increasing orders for this paragon of perfection, at a price, of course. You need have no worry; it is as dear as any other.

STAINLESS STEEL WIRE CO. LIMITED
THE BARRACKS · LANGSETT ROAD · SHEFFIELD, 6
Telephone: SHEFFIELD 44241 Telegrams: FINEWYRE SHEFFIELD



An Important Amenity

Friction between employees, and confusion at going-home time may be avoided by providing separate receptacles for clothes and personal belongings. Such provision is also important in the interest of hygiene. 'Harco' Clothes Lockers provide the answer. They are made in sheet metal or wirework, in nests of up to five in one unit, with short or full length compartments as required. Steel lockers are fitted with six-lever locks which can differ up to 1600; wirework lockers have rings for padlocks. Height of both types is 72 ins.

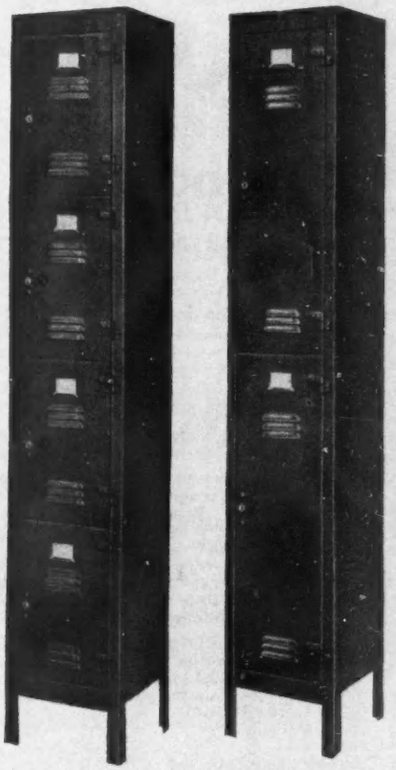
WIREWORK LOCKERS

Standard sizes:

72 in. high x 12 in. wide x 12 in. deep

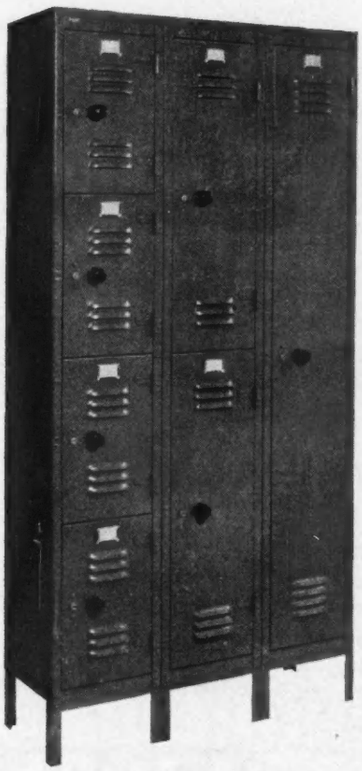
72 in. high x 10 in. wide x 18 in. deep

Please send for List No. E 1009



Wirework or Sheet Metal

in single units or nests of 2-5 as required



STEEL LOCKERS

Overall sizes:

72 in. high x 12 in. wide x 12 in. deep

72 in. high x 15 in. wide x 15 in. deep

72 in. high x 18 in. wide x 18 in. deep

1, 2 or 4 compartments per locker

Please send for List No. E 960

'Harco' Clothes Lockers

ARE HYGIENIC, DURABLE AND EASY TO INSTALL

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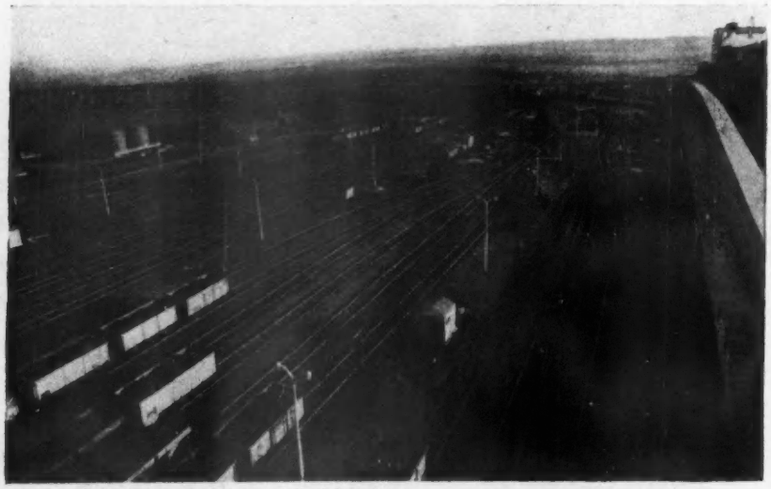
MANVERS CENTRALIZATION SCHEME :

From the top of the newly constructed Coal preparation plant : a small section of the immense network of railway sidings

The supply and installation of these sidings and the adjoining trackwork for the new Coal Carbonization and Benzole Rectification Schemes were entrusted to the Eagre Construction Co., Ltd., by the National Coal Board. Over 9,000 tons of Iron and Steel were used in the construction of the forty miles of track and 230 turnouts and Special Point and Crossing layouts comprising the combined railway Sidings.

Eagre's skilful planning and practical experience in the day-to-day working of Colliery Sidings ensured that this vast scheme was laid efficiently to schedule, and without the slightest interruption of existing Colliery traffic.



Photograph by courtesy of National Coal Board

WORK BEGINS AT CADEBY :

The National Coal Board again entrusts the Eagre Construction Co. Ltd. with a similar project. Earthworks, Drainage, Track Laying and ancillary works for thirteen miles of Sidings are now in progress at Cadeby Main.

for a complete Track Service

Photograph by courtesy of National Coal Board

In addition to its activities in the Nation's Coalfields, the Eagre Construction Co. Ltd. has worked continuously during the past ten years for British Railways, the Gas Board, the United Steel Companies, and has carried out large Power Station Projects for the Central Electricity Authority.

SURVEY
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Whatever the magnitude of your siding requirements, be sure to consult

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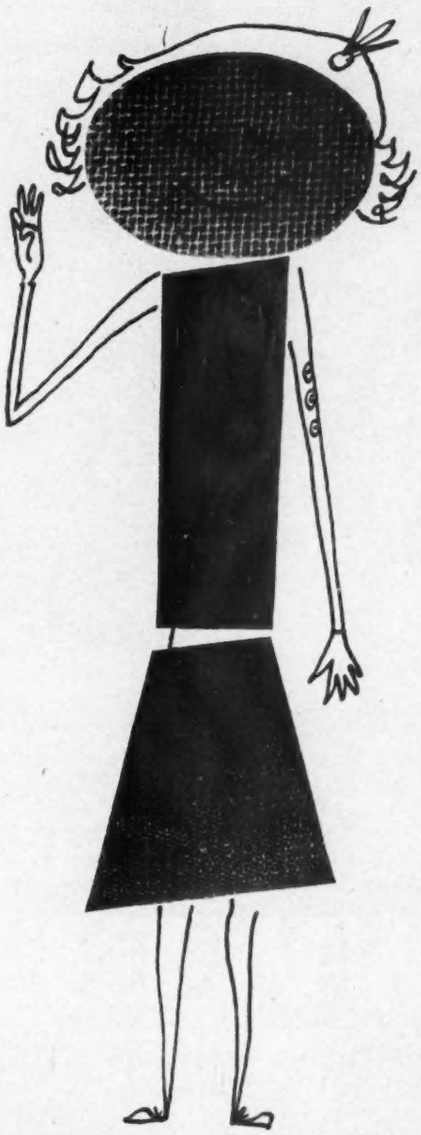
EAGRE

Telephone: Scunthorpe 4513-7

Guides are made of Ferobestos



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high temperature resistance
low moisture absorption
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high dimensional stability
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The versatility of Ferobestos, an asbestos-reinforced plastic material, opens up an extremely wide range of engineering applications.
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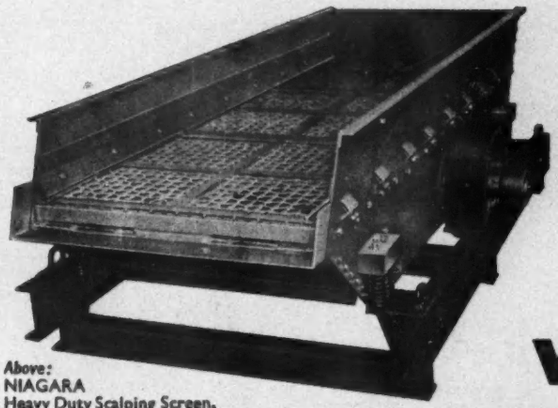

Above:
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Heavy Duty Scalping Screen. Can also be supplied in portable form with elevators and conveyors.
Circle: Fitted with any mesh.
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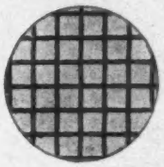

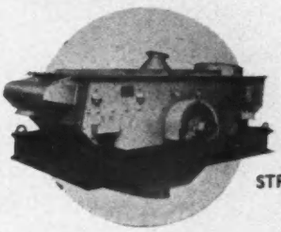

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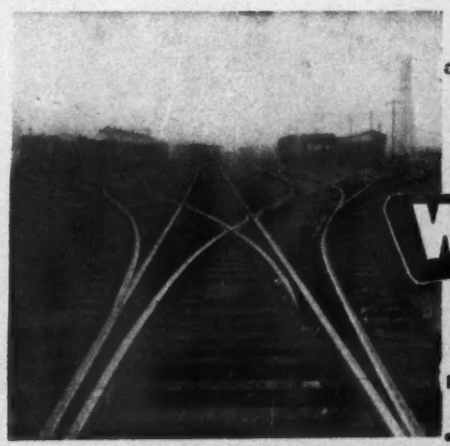

Whatever your Railway or Tramway problem and however intricate "Whites" specialists can help you.

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With acknowledgements to the North Western Gas Board to whom we are indebted for the privilege of taking this photograph.

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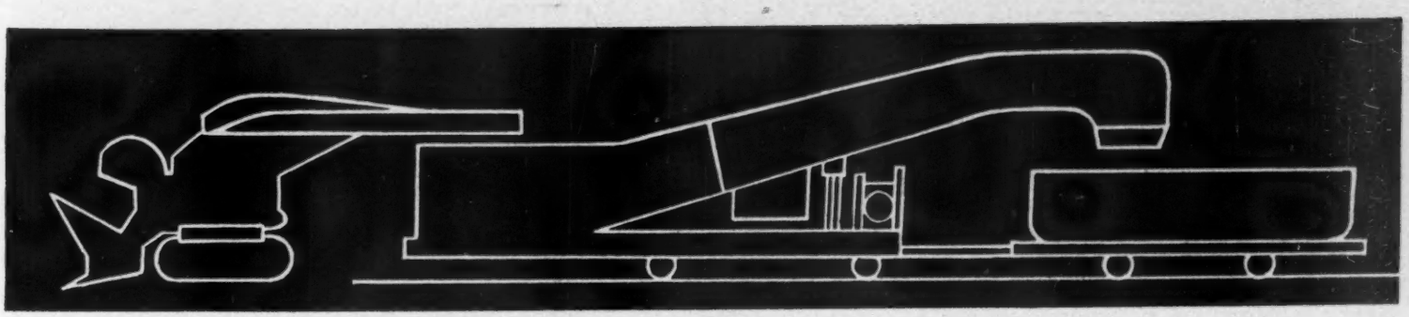

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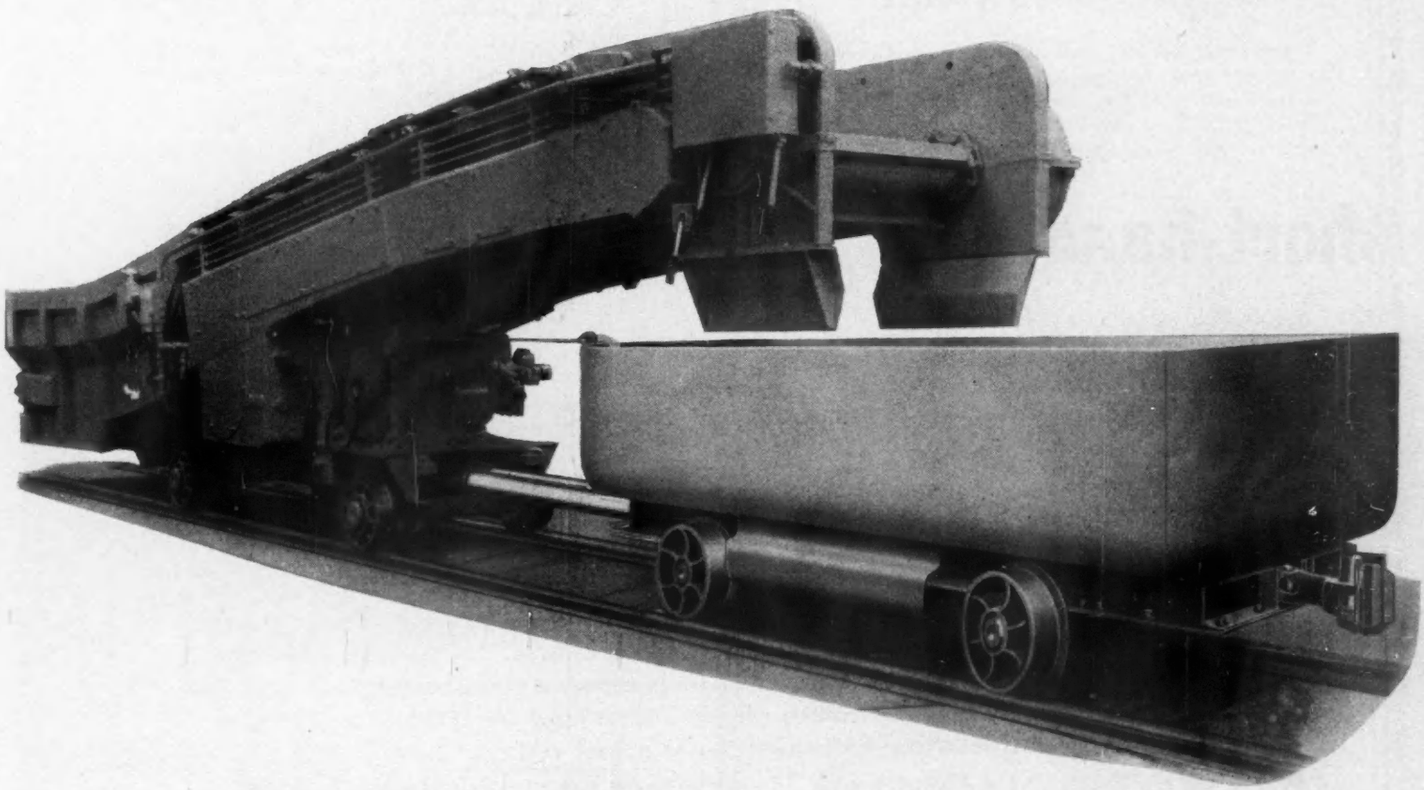
with the aid of
"ALLEN-SOTIM" ACCUMULATOR CAR



With the need for increased drivage in Stone headings, Tunnels, etc., the car-changing time is a vital consideration.

The " ALLEN-SOTIM " ACCUMULATOR CAR has been designed to act as a link which keeps the loader working to capacity and at the same time ensures a flow of car loading with a minimum of man-power.

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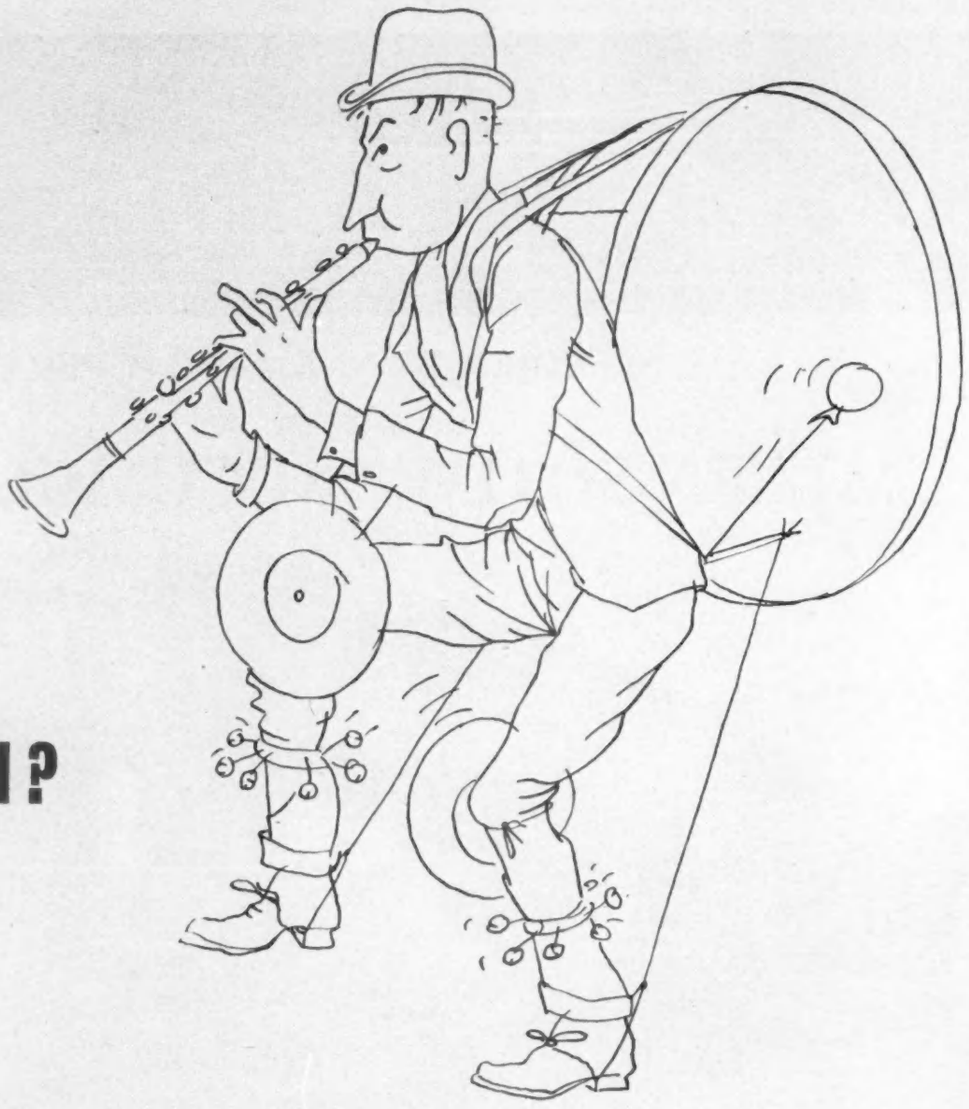

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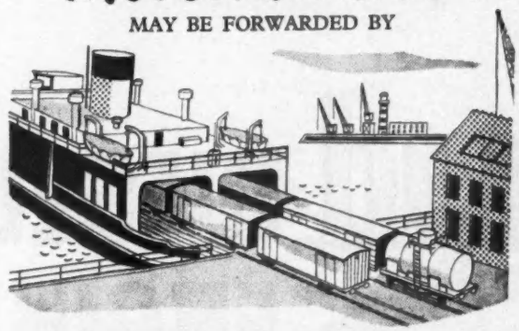

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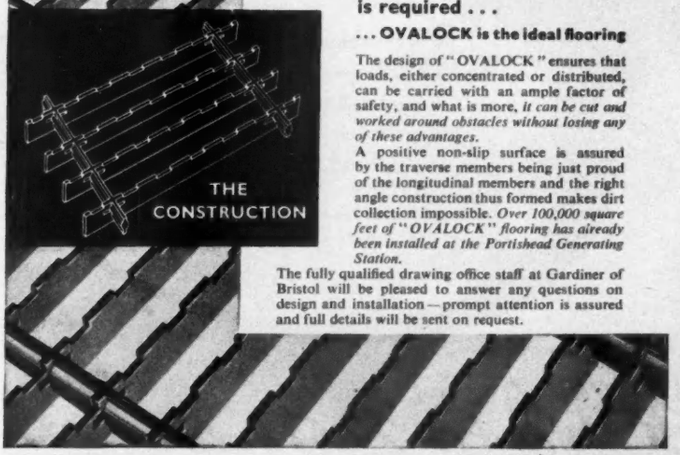
OVALOCK
REGD.
FLOORING



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. . . OVALOCK is the ideal flooring

The design of "OVALOCK" ensures that loads, either concentrated or distributed, can be carried with an ample factor of safety, and what is more, *it can be cut and worked around obstacles without losing any of these advantages.*

A positive non-slip surface is assured by the traverse members being just proud of the longitudinal members and the right angle construction thus formed makes dirt collection impossible. *Over 100,000 square feet of "OVALOCK" flooring has already been installed at the Portishead Generating Station.*

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The fully qualified drawing office staff at Gardiner of Bristol will be pleased to answer any questions on design and installation—prompt attention is assured and full details will be sent on request.

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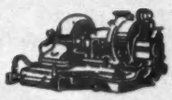

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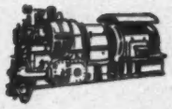

Turbine driven up to 11,000 KW.
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Scores in hand, hundreds in service.

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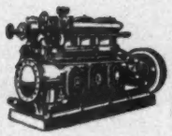

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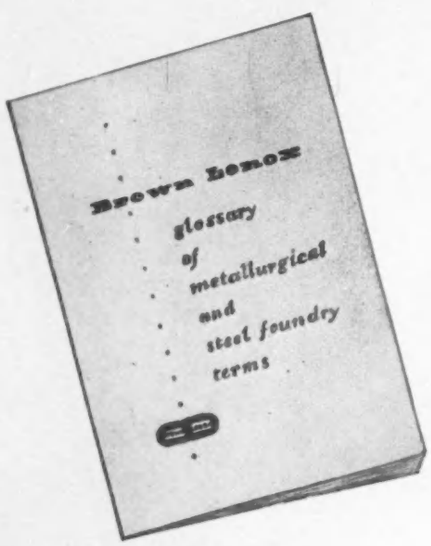
A MACHINED Steel Casting

by Brown Lenox



This pocket-size Glossary covers 174 metallurgical and steel foundry terms. We should be very pleased to send you a copy.

Our steel foundry sales are rising; we are making more steel castings for the engineering industry today, than we were a year ago.

We do really try to quote quickly and deliver on time; and we have no hesitation in tackling difficult castings. Our steel foundry staff, including Mr. J. Cameron our Foundry Manager—"Joe" to his many friends—is always on call to discuss with our customers, in their own works, problems relating to *design* and *castability*.

We make castings up to 4 tons in weight in carbon, and low and medium alloy steels.

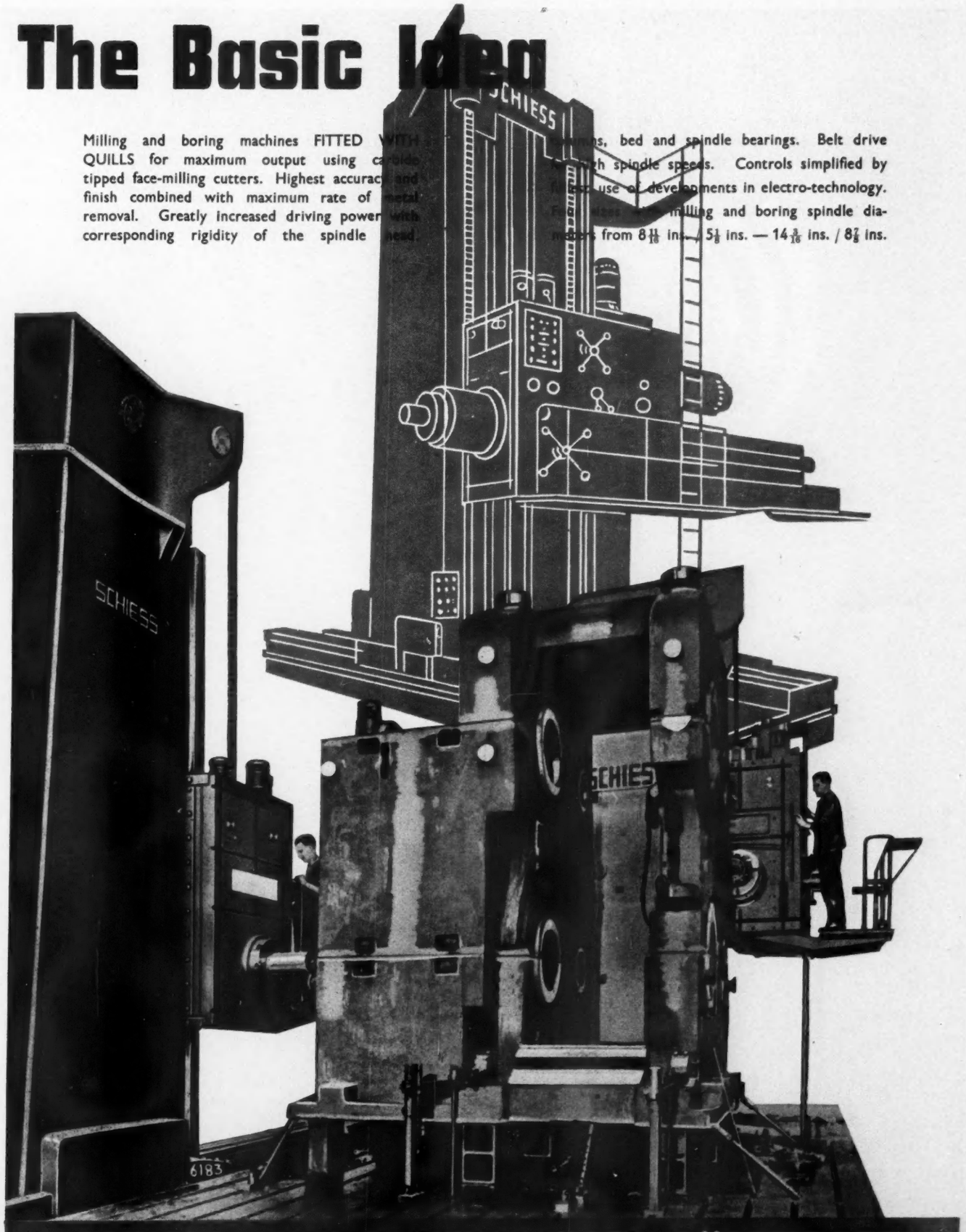
An announcement by the Industrial Division of

BROWN, LENOX & COMPANY LIMITED
Associated Company : Brown, Lenox & Co. (London) Ltd., Millwall, E.14
PONTYPRIDD GLAMORGAN

The Basic Idea

Milling and boring machines FITTED WITH QUILLS for maximum output using carbide tipped face-milling cutters. Highest accuracy and finish combined with maximum rate of metal removal. Greatly increased driving power with corresponding rigidity of the spindle head.

...ns, bed and spindle bearings. Belt drive ...th spindle speeds. Controls simplified by ... use of developments in electro-technology. ... milling and boring spindle diameters from $8\frac{11}{16}$ ins. / $5\frac{1}{8}$ ins. — $14\frac{3}{16}$ ins. / $8\frac{7}{8}$ ins.



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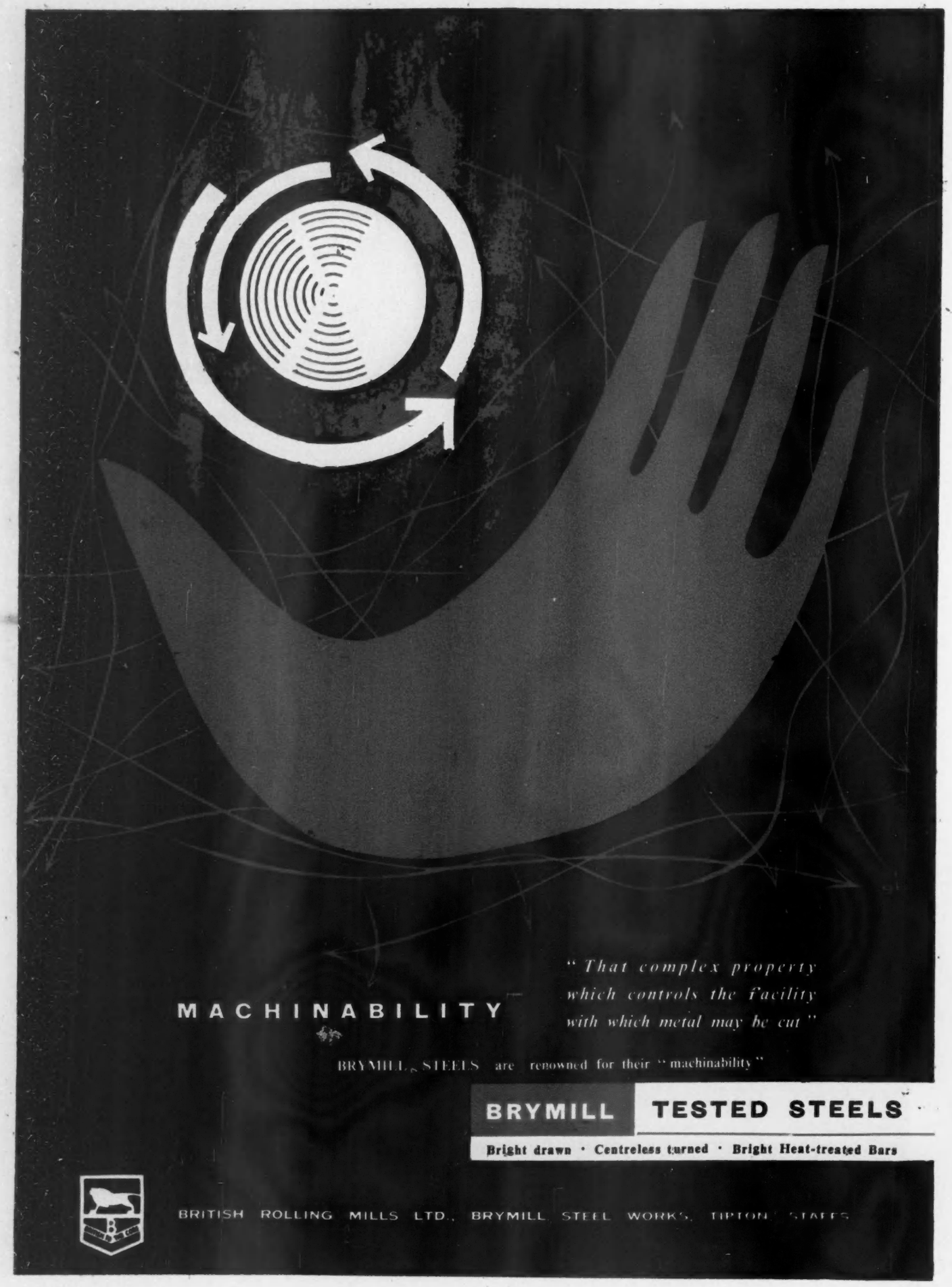
Sole Agents United Kingdom and Eire, BURTON, GRIFFITHS & CO. LTD. BIRMINGHAM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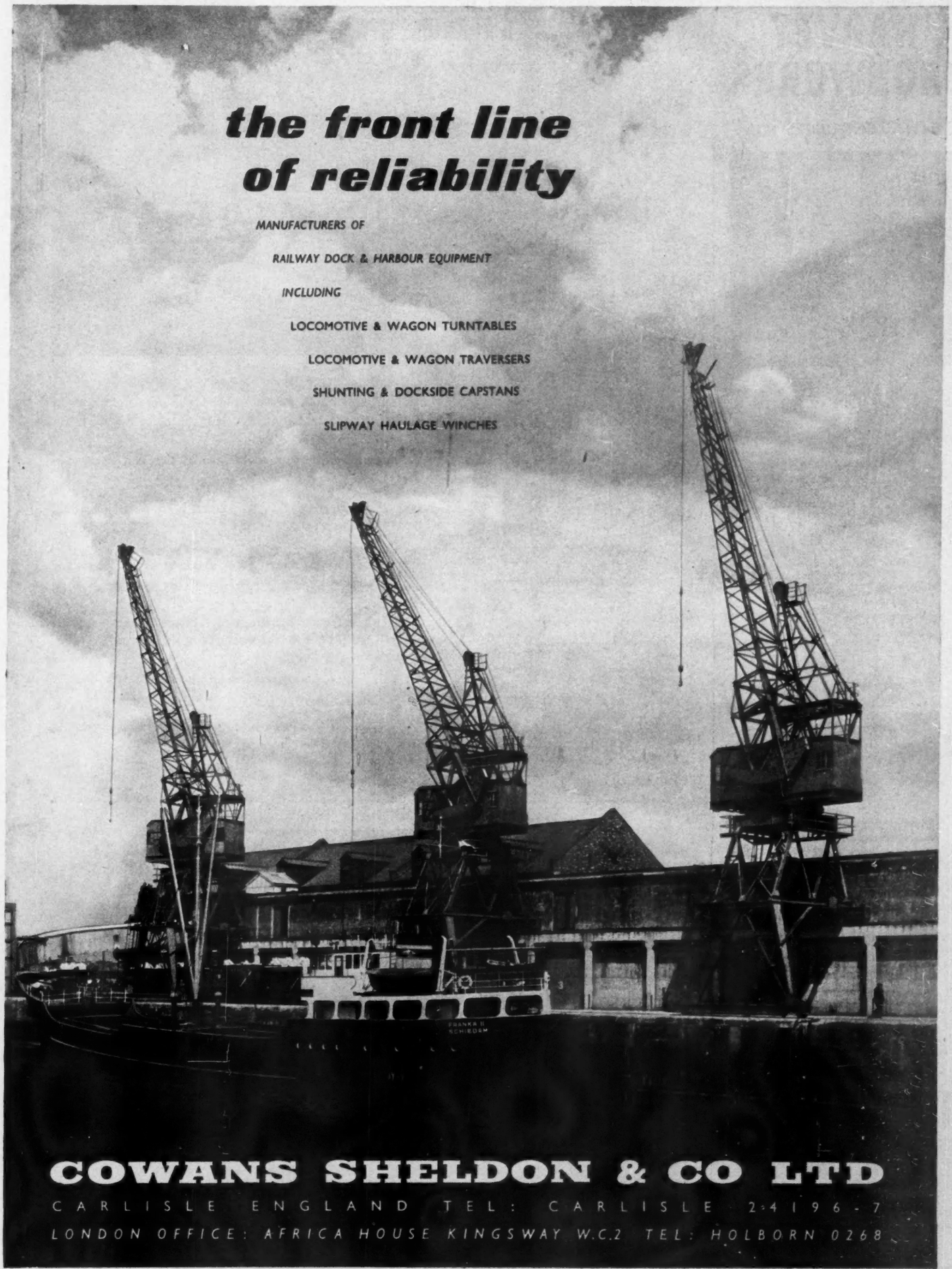
"That complex property which controls the facility with which metal may be cut"
BRYMILL STEELS are renowned for their "machinability"
BRYMILL TESTED STEELS
Bright drawn · Centreless turned · Bright Heat-treated Bars
BRITISH ROLLING MILLS LTD., BRYMILL STEEL WORKS, TIPTON, STAFFS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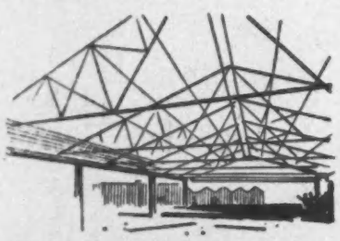

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Tel: WEST BROMWICH 2193

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for MAIN ROAD lighting

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- Side entry mounting, the bracket being concealed within the lantern body.
- Modern body design incorporating concealed hinges and catches supporting the " Perspex " enclosure.
- Optical control obtained by " Perspex " refractor plates bonded one to each inner side of a " Perspex " bowl.
- Tube operating gear housed within the lantern body.
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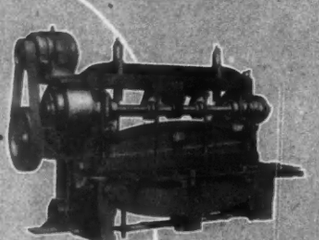

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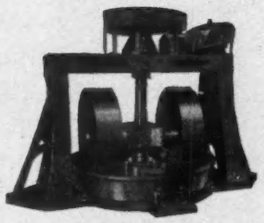

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of all types including

AIRLESS WHEELBLAST PLANTS

Over 50 years experience embodied in design and manufacture

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10 ton Steam Permanent Way Crane. Metre Gauge. Duty: 10 tons at 16 ft. radius propped; 5 tons at 14 ft. radius free

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FOR FACTORY MAINTENANCE

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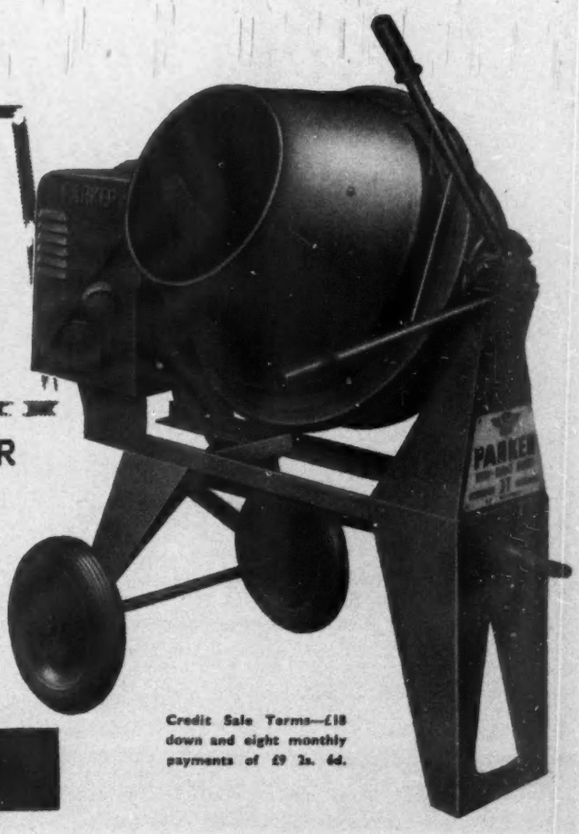
4/3 CU.FT. CAPACITY

HALF-BAG CONCRETE MIXER



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STEEL FABRICATED
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WITH OR WITHOUT
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Tanks, any size or shape fabricated and rubber, lead or plastic lined to your specification.

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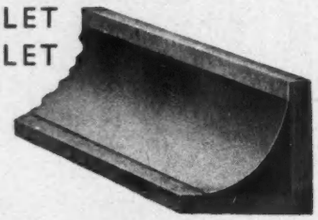

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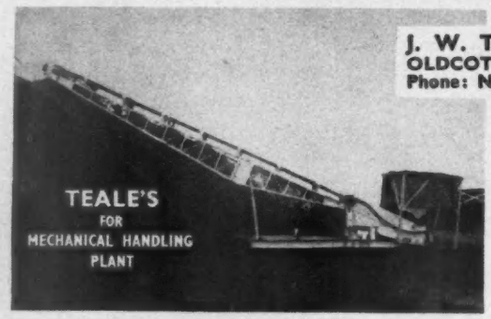

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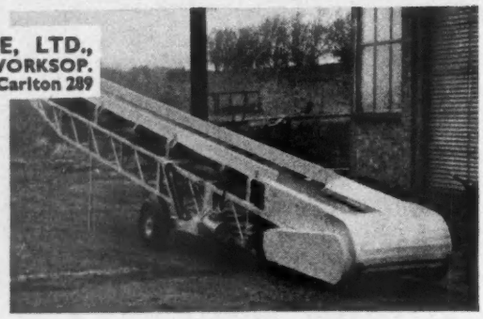

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Continuous and Automatic

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PRESSURE RANGE 0-250 P.S.I.

Direct Solenoid Operated. Lightweight. Fast Operation

Size range 1/4in. — 3/8in. B.S.P. A.C. or D.C. Supply. Dust-tight Cover

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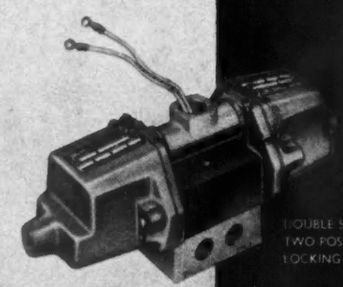
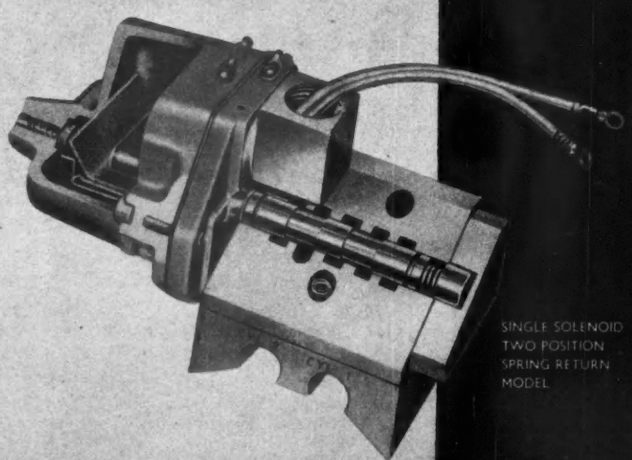


DOUBLE SOLENOID TWO POSITION LOCKING MODEL



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THE WELLMAN SMITH OWEN ENGINEERING CORPORATION LTD.
PARNELL HOUSE, WILTON ROAD, LONDON, S.W.1 WORKS: DARLASTON, South Staffs, & BELFAST.

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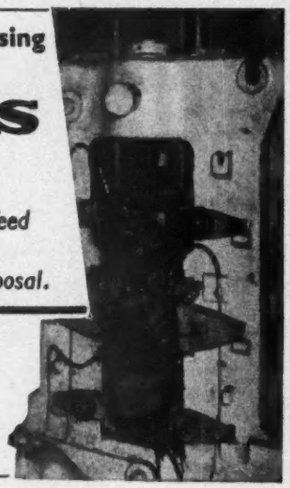
Lubricants

A typical conversion to forced feed lubrication.

Our engineers are at your disposal.



IRONSIDES SHIELD PRODUCTS

THE IRONSIDES LUBRICANTS LTD.,
Daw Bank, Stockport.
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New threads for old..

in damaged components

Hard tough threads in soft materials, used and approved by the Aircraft industry designed for use in soft metal components wood or plastics. Simple to use, remains permanently in place. Full range of standard sizes in B.S.W.: B.S.F.: B.S.P.: B.A., U.N.F.: U.N.C. and Metric thread forms.

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Specialists in JET ENGINE LABYRINTHS, CIRCLIPS, SPRING WASHERS, SPRINGS etc.

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HIGH QUALITY ENGINEERING & MACHINE TOOL CASTINGS

HEAT & WEAR RESISTING UP TO 10 TONS also in SPHEROIDAL GRAPHITE IRON & STEEL

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Non Acid. Non Corrosive. Jizer applied by brush or spray removes Grease, Grime and Oily deposits from floors, walls and windows easily and is ideal for the removal of cutting oils, or oil smears from all metals prior to processing. Last but by no means least use JIZER for machinery cleaning. A clean machine leads to increased efficiency and pride in the job.

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Swarfega Antiseptic Handcleanser removes all industrial soiling from the hands be it oil, paint, tar, rubber compounds or just ingrained grime. Leaves hands in a clean healthy condition. Work people think it ideal. Moreover it can be dispensed from completely wasteproof containers which offer Management economy, convenience and make for ease of distribution. Swarfega therefore is the answer for both interested parties.

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the best instrument for the job...

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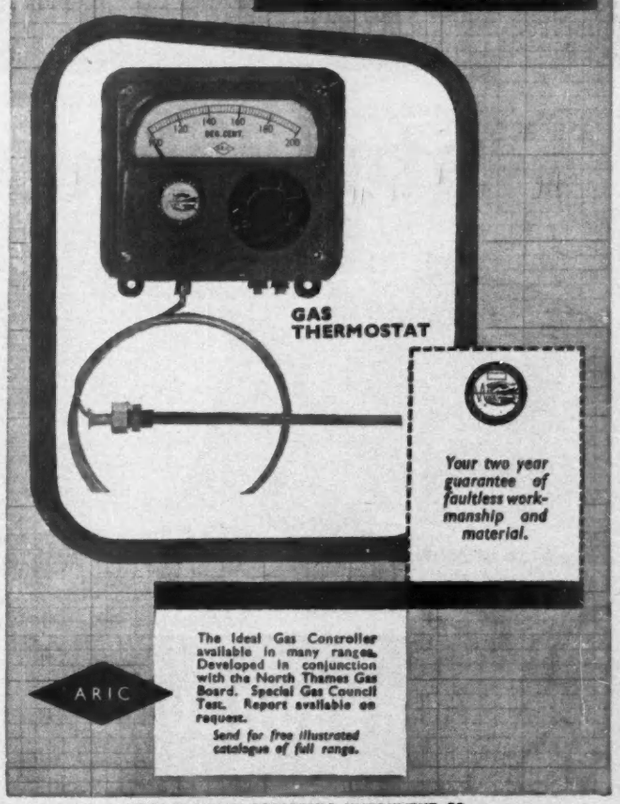
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Your two year guarantee of faultless workmanship and material.
The Ideal Gas Controller available in many ranges. Developed in conjunction with the North Thames Gas Board. Special Gas Council Test. Report available on request.
Send for free illustrated catalogue of full range.
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Water screening plant

Write for list Nos. 212, 213 and 225.

A high quality range of power-driven continuously self-cleaning equipment, including Travelling or Band Screens in alternative forms, and Revolving Screens of Disc, Cup and Drum Patterns, providing a full choice for free water-level conditions; also enclosed rotary disc types for pipeline use. Automatically controlled operation, according to time schedule or changes in conditions, can be arranged to meet special requirements.

Built to the most advanced specifications for efficient service, with low operating costs, maximum resistance to wear and corrosion, and ability to withstand full overload in emergency, these Blakeborough types have proved their value on many installations in this country and abroad.

The illustration shows a battery of Travelling screens of the high capacity "Twinflow" type on power station circulating water service.

BLAKEBOROUGH

J. BLAKEBOROUGH & SONS LTD.,

BRIGHOUSE, ENGLAND

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Lineage Rate. 4/- per line of approximately 6 words. Minimum 16/-.

Inch Rate. 48/- per single column inch and *pro rata*. 12 lines to 1 inch.
There are reduced rates (*i.e.*, not on a *pro rata* basis) for advertisements of ¼-page (12 column inches) and upwards, e.g., ½-page £25 10s. ¼-page £48. Full page £90.

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Series Discounts. For advertisements 1 inch and upwards. 6 insertions 5%. 13 insertions 10%. 26 insertions 15%.

Run-on and Semi-Displayed Styles. Both these styles are available for single column width advertisements of any depth up to 12 inches.

Displayed and Illustrated Styles. The minimum size for a Displayed advertisement is 3 inches single column, for an illustrated advertisement it is a ¼-page (12 column inches). Thereafter the sizes for both progress in steps 3 inches deep across 1, 2, 3 or 4 columns.

Use of Box Number. 2/- which includes forwarding of replies.

Copy Dates. "Run-on" and "Semi-displayed" advertisements by noon Tuesday for publication on Friday same week. "Displayed" and "Illustrated" advertisements by noon Friday for publication on following Friday. All advertisements three days earlier if proofs are required.

***Advertisements for publication should be addressed to:*—Classified Advertisement Dept., "The Engineer", 28 Essex Street, Strand, London, W.C.2.**

Urgent advertisements may be telephoned to CENtral 6565.

PUBLIC APPOINTMENTS

CARMARTHENSHIRE EDUCATION COMMITTEE

LLANELLY TECHNICAL COLLEGE

FULL-TIME ASSISTANT MASTER

Applications are invited for the post of FULL-TIME ASSISTANT MASTER IN ENGINEERING WORKSHOP PRACTICE AND ALLIED SUBJECTS at the above-named College.

Candidates should possess a full Technological Certificate of the City and Guilds of London Institute in Engineering Machine Shop Practice and have served a recognised Engineering Apprenticeship with subsequent industrial experience. Teaching experience in a Technical College will be an added recommendation.

Salary in accordance with the Burnham Further Education Report, 1956, for Grade A Assistants (£475 by £25 to £900). Increments will be allowed for approved training, industrial experience, &c.

Duties to commence on 1st January, 1959.

Forms of application, which must be returned not later than 30th August, 1958, may be obtained from the undersigned on receipt of a stamped, addressed envelope.

IORWERTH HOWELLS,
Director of Education.

County Education Offices,
County Hall,
Carmarthen. E8200

SINGAPORE POLYTECHNIC

SENIOR LECTURER IN ELECTRICAL ENGINEERING

The Board of Governors invite applications from University graduates and/or graduate members of a Professional Institution, with good industrial and teaching experience in Technical College or University. First duties will include completing equipment for 1st Class electrical machines and measurements laboratories and installation workshops.

Salary, incorporating all allowances: M$1800 by M$50 to M$1950 per month. (The Malayan Dollar=2s. 4d. Sterling.)

Appointment of overseas person will be on Contract for 6 years with option of renewal for further 3 years. Favourable Endowment Insurance Scheme; or arrangements to continue F.S.S.U. policy might be made. Accommodation, with heavy furniture, at a rental of M$120/- per month; free medical attention; free passages for overseas member of Staff, wife and up to 3 children under 18, on first appointment, leave and completion of service; home leave at the rate of sixty days per year's service; tour will not normally exceed 2 years.

Application forms (4 copies) and further information obtainable from The Council for Overseas Colleges, 12, Lincoln's Inn Fields, London, W.C.2. Closing date 18th August, 1958. E8240

IPSWICH CIVIC COLLEGE

Principal: F. METCALFE, B.Sc. (Eng.), M.I.Mech.E.

ASSISTANT, GRADE B, FOR MECHANICAL/ELECTRICAL ENGINEERING

Applications are invited for the post of ASSISTANT, Grade B, for MECHANICAL/ELECTRICAL ENGINEERING. Salary: Grade B Scale, Burnham Technical Report, £650 by £25 to £1025 per annum. Commencing salary will be subject to allowances for Degrees, training and industrial experience.

Forms of application and further particulars obtainable from the Principal, Civic College, Rope Walk, Ipswich, to whom completed forms should be returned as soon as possible.

J. T. HILL,
Chief Education Officer.

Education Department,
17, Tower Street,
Ipswich. E8215

ST. THOMAS' HOSPITAL

LONDON, S.E.1

SENIOR ENGINEER

Salary: £770–£920, including London Weighting.

Details of the appointment and qualifications required upon application to the Personnel Officer.

Closing date for applications, with names of 2 referees, 1st September. E8218

PUBLIC APPOINTMENTS

NORTH WEST METROPOLITAN REGIONAL HOSPITAL BOARD AND MID HERTS GROUP HOSPITAL MANAGEMENT COMMITTEE

GROUP SUPERINTENDENT ENGINEER

Applications are invited for the appointment of a GROUP SUPERINTENDENT ENGINEER who will be responsible for the engineering services of all hospitals in the Group.

Applicants must have completed an apprenticeship in mechanical engineering and have a sound knowledge of the principles and practice of the efficient operation of steam boiler plants and have a wide experience in the supervisory position of such types of mechanical and electrical services as are found in hospitals. Candidates must have passed an examination in engineering technology and hold First-class Certificate of Competency in Marine Engineering or an equivalent qualification.

In addition to the normal work of the Group which is calculated in the 40½–50 points range, the successful candidate will be required to supervise some of the engineering works during the building of the new Welwyn Hospital under the direction of the Regional Board's Engineer. This will have the effect of raising the points count for salary purposes to the 50½–60 points range. Ultimately the Superintendent Engineer will assume day-to-day responsibility for the Welwyn Hospital when it is handed over by the Regional Board and will be expected to reside in the hospital house to be provided.

Salary scale: £1040 to £1215 per annum.

Applications, giving details of age, experience and qualifications, together with the names of three referees, should be sent to the Group Secretary, Bleak House, Catherine Street, St. Albans, by 15th September, 1958. E8217

ROYAL NAVAL SCIENTIFIC SERVICE

SENIOR SCIENTIFIC OFFICERS AND SCIENTIFIC OFFICERS

Royal Naval Scientific Service requires SENIOR SCIENTIFIC OFFICERS and SCIENTIFIC OFFICERS for Establishments in London area, Baldock, Portsmouth, Portland, Poole, Greenock and Rosyth. Main requirements are about 25 vacancies for PHYSICISTS, ELECTRONIC ENGINEERS and MATHEMATICIANS in areas specified. The following particular vacancies also exist: MECHANICAL ENGINEER for work on gas turbine problems in the London area. MECHANICAL ENGINEER for work on design and development of U/W devices in Portland area. METALLURGISTS for Rosyth and Poole. CHEMISTS (Physical and Inorganic) for Poole area, Baldock and London. Candidates must normally be natural born British subjects of natural born British parents, with at least First or Second Class Honours degrees or equivalent high professional attainments. S.S.O.s must have had at least three years' post-graduate experience and be not less than 26 years of age. Salaries (men) S.S.O. £1190–£1410; S.O. £635–£1110 (London)—somewhat lower in provinces. Appointments unestablished (with F.S.S.U. benefits), but opportunities may occur for those between the ages of 21 and 32 to compete for established posts.—Forms from M.L.N.S., Technical and Scientific Register (K), 26, King Street, London, S.W.1, quoting A98/8A. E8092

BIRMINGHAM REGIONAL HOSPITAL BOARD

APPOINTMENT OF REGIONAL ENGINEER

Wide experience essential in design and operation of engineering plant, especially of heating, hot water and ventilating systems, preferably in hospitals or large undertakings. Essential qualifications: Corporate Membership of Institutions of Civil, Mechanical or Electrical Engineers or appropriate engineering appointment of professional grade in hospital service. REGIONAL ENGINEER will be whole-time officer responsible to Board for efficient working of his department; salary £1885 by £80 (1) by £85 (4) by £50 (1) to £2355. Further particulars from Secretary, Regional Hospital Board, 10, Augustus Road, Birmingham, 15. Applications naming three referees to be received by 1st September, 1958. Interviews mid-September. E8103

PUBLIC APPOINTMENTS

COUNTY BOROUGH OF DONCASTER

SENIOR ASSISTANT ENGINEERS

Applications are invited for the following appointments on the permanent staff of the Borough Surveyor and Water Engineer.

(a) Post A.4—SENIOR ASSISTANT ENGINEER APT. Grade IV (£1025–1175).

(b) Post A.5—SENIOR ASSISTANT ENGINEER (Mechanical) APT. Grade IV (£1025–£1175).

Applicants for appointment (a) must be Corporate Members of the Institution of Civil Engineers and/or the Institution of Municipal Engineers and have had considerable experience of municipal engineering work. Experience of Main Drainage and Sewage Disposal Schemes would be deemed advantageous.

Applicants for appointment (b) should be Corporate Members of the Institution of Mechanical Engineers though possessors of an alternative professional qualification would be considered. The person appointed will be responsible for the preparation and supervision of schemes carried out by Contract and Direct Labour for the installation, maintenance, repair and replacement of plant and equipment belonging to the Highways Department, Sewerage and Sewage Disposal Undertakings and Public Baths.

The appointment will be subject to the Conditions of Service of the National Joint Council, terminable by one month's notice on either side, and to the provisions of the local Government Superannuation Acts. The successful candidate will be required to pass a medical examination.

Applications stating age, qualifications, past and present appointments and salary, together with full details of experience and the names of two Referees, are to be delivered to the Borough Surveyor and Water Engineer at 2 Priory Place, not later than Monday, the 1st September, 1958.

Candidates must state in writing whether or not they are related to any members or Senior Officer of the Council.

H. R. WORMALD,
Town Clerk.

1, Priory Place,
Doncaster.
2nd August, 1958. E8234

DUNMOW RURAL DISTRICT COUNCIL

APPOINTMENT OF ASSISTANT RESIDENT ENGINEER

Applications are invited for the above appointment on the staff of the Resident Engineer for the construction of sewerage and sewage disposal works, under the direction of the Consulting Engineers, J. D. and D. M. Watson, M.M.I.C.E., 67, Tufton Street, Westminster, S.W.1. Applicants should be suitably qualified and preferably have some knowledge of sewerage and sewage disposal design.

The salary offered will be between £600 and £800 per annum, according to qualifications and experience. The appointment will be subject to one month's notice on either side and, subject to satisfactory service, is expected to last at least a year. Some travelling is likely to be necessary and if the person appointed uses his own car on duty the Council will pay a travelling allowance at a rate not exceeding that payable for a 10 H.P. or 1199 c.c. vehicle, in accordance with the National Scheme of Conditions of Service.

Applicants should apply by August 21st, 1958, in writing, to the undersigned, giving full particulars of age, qualifications and experience, and enclose copies of not less than two testimonials or the names of two referees.

A. H. BURTON,
Clerk of the Council.

Council Offices,
Dunmow,
Essex. E8171

CITY GENERAL HOSPITAL

STOKE-ON-TRENT

(815 BEDS)

ASSISTANT ENGINEER

ASSISTANT ENGINEER required. Applicants should have served an apprenticeship in mechanical engineering and the possession of a recognised technical qualification will be an advantage.

Salary: £555–£675 per annum. Appointment subject to N.H.S. (Superannuation) Regulations.

Applications, giving details of training and subsequent experience (two referees), to Hospital Secretary, not later than 23rd August, 1958. E8216

PUBLIC APPOINTMENTS

GHANA

TEMA DEVELOPMENT CORPORATION

ENGINEERS

Applications are invited for the following posts on contract for two tours of 18–24 months each with possible extensions:

SENIOR ENGINEER.—Candidates for this post must be A.M.I.C.E./A.M.I.Mun.E. with a minimum of five years' post-qualification experience. Salary scale: £1660 by £60 to £2080, point of entry according to age and experience.

ENGINEERS.—Candidates must hold a minimum qualification of (a) Engineering Degree, plus two years post-graduate experience; or (b) Sections A and B, Institution of Civil Engineers; or (c) Testamur Examination, Institution of Municipal Engineers. Salary scale: £1080 by £50 to £1580; £1660 by £60 to £2080, point of entry and subsequent upgrading to upper segment of scale, according to age, qualifications and experience.

Successful candidates will be required to join the Corporation's Provident Fund by making a contribution of 7½ per cent of salary to it against the Corporation's contribution of 17½ per cent.

Duties: Design and preparation of contract documents for road construction and main sewerage and surface water drainage schemes. Experience in earthworks and road construction by soil stabilisation will be an advantage. Persons appointed may be required to work on the site as Resident Engineer or Assistant Resident Engineer, with responsibility for supervision of such works both by contract and direct labour.

For further particulars and application forms, write, stating age, qualifications and experience to: THE DIRECTOR OF RECRUITMENT, GHANA HIGH COMMISSIONER'S OFFICE, 13, BELGRAVE SQUARE, LONDON, S.W.1. E8242

NATIONAL COAL BOARD

NORTH EASTERN DIVISION

CIVIL ENGINEERING ASSISTANTS

National Coal Board, North Eastern Division, require the following in the Reconstruction Engineer's Office at Doncaster.

(a) CIVIL ENGINEERING ASSISTANT. Salary £1050–£1600 per annum. Applicants should be Corporate Members of the Institution of Civil Engineers and have experience in the design and construction of industrial buildings and structures and general civil engineering works. Consideration will be given to Corporate Members of the Institution of Structural Engineers with suitable engineering experience. Duties will include planning and design for the civil engineering works associated with major reconstruction schemes.

(b) CIVIL ENGINEERING ASSISTANT. Salary £900–£1400 or £750–£1150. Applicants should be Corporate Members of the Institution of Civil or Structural Engineers, or actively preparing to qualify for membership of these Institutions, and should have general experience in civil engineering work, preferably in relation to industrial buildings and structures.

Apply, giving full details including age, present post and salary to the Staff Director, Holmwood House, Ecclesall Road South, Sheffield, 11, by 25th August, marking envelopes AA/391 for vacancy (a) and AA/392 for vacancy (b). E8237

WELLAND RIVER BOARD

UPPER REACHES

DISTRICT ENGINEER

Applications are invited for the above post in A.P.T. Grade III or IV (£875–£1175), according to experience. The post will be superannuated with car allowance according to N.J.I.C. Scale. The successful applicant will be required to live in or near Stamford, Lincs. Preference will be given to qualified Civil Engineers who have had experience in similar land drainage work.

Apply at once to the undersigned.

E. G. TAVERNER, M.S.E.,
Engineer to the Board.

Welland House,
Double Street,
Spalding, Lincs. E8211

Classified Advts. continued on page 100

PUBLIC APPOINTMENTS

STAFFORDSHIRE POTTERIES WATER BOARD

APPOINTMENT OF CIVIL ENGINEERING ASSISTANTS AND DRAUGHTSMEN

Applications are invited for the following appointments :—

(1) THREE CIVIL ENGINEERING ASSISTANTS (Temporary), Grade A.P.T. IV (£1025 to £1175 p.a.). These appointments are not on the permanent staff, but will be for not less than three years. Applicants must be Corporate Members of the Institution of Civil Engineers and have had experience in the design and construction of at least one of the following :—Pumping stations, filtration plant, reinforced and mass concrete service reservoirs and aqueducts.

(2) CIVIL ENGINEERING ASSISTANT, Grade A.P.T. III (£845 to £1025 p.a.). Applicants should be Corporate Members of the Institution of Civil Engineers and preferably have had experience in the design and construction of waterworks.

(3) DRAUGHTSMAN (MECHANICAL), Grade A.P.T. II (£725 to £845 p.a.). Applicants should be neat and expeditious draughtsmen with a knowledge of plant layout.

(4) DRAUGHTSMAN (Distribution Department), Misc. Grade IV (£540 to £620). Applicants should be neat and expeditious draughtsmen. Previous experience with a waterworks undertaking is desirable, but not essential.

For appointments (1) and (2) the Board will provide housing accommodation for the successful candidates if required.

Reasonable removal expenses will be allowed by the Board.

The appointments are subject to the provisions of the National Scheme of Conditions of Service ; to the provisions of the Local Government Superannuation Act, 1937 ; to termination by one month's notice on either side, and to the successful candidates passing a medical examination.

The Board have considerable major works in hand which are to be completed within the next three to five years. These works include the development of an impounding reservoir scheme with the design and construction of pumping station, filtration plant, aqueducts up to 40in diameter, and concrete service reservoirs up to 10 million gallons capacity.

Applications, stating age, full details of training, qualifications, present and previous appointments, details of experience, together with copies of two recent testimonials, or the names of two persons to whom reference can be made, and clearly stating for which post they are applying, should be forwarded to the undersigned not later than Monday, 25th August, 1958.

C. V. BROWN,
M.I.C.E., M.I.Mech.E., M.I.W.E.,
Engineer and Manager and Clerk.

Albion Street,
Hanley,
Stoke-on-Trent. E8247

KING GEORGE V HOSPITAL

GODALMING, SURREY

SENIOR ENGINEER

SENIOR ENGINEER required. The person appointed will be responsible for the satisfactory operation and co-ordination of the engineering and maintenance services of the hospital. Oil-fired Economic boilers with electrical generating installation and all usual hospital services and equipment. Applicants should have completed an apprenticeship in mechanical engineering or have acquired a thorough practical mechanical engineering training. House available in hospital grounds at an inclusive rent, at present £5 6s. 8½d. per month. Salary scale : £615–£740 per annum. Contributory pension scheme.

Apply, giving names of referees, to Group Secretary, Milford Chest Hospital, Godalming, Surrey, not later than 15th August, 1958. E8207

WELLAND RIVER BOARD

ASSISTANT ENGINEER AND SURVEYOR

Applications are invited for the above post in A.P.T. Grade II or III (£725–£1025), according to experience. The post will be superannuated with car allowance according to N.J.I.C. Scale. The successful applicant will be required to live in or near Spalding, Lincs. Preference will be given to partly qualified civil engineers who have had experience in land drainage work.

Apply at once to the undersigned.

E. G. TAVERNER, M.S.E.,
Engineer to the Board.

Welland House,
Double Street,
Spalding, Lincs. E8226

BRITISH RAILWAYS

WESTERN REGION

SENIOR ENGINEERING ASSISTANTS

Applications are invited for two posts of SENIOR ENGINEERING ASSISTANTS in the Civil Engineering Department at Paddington Station, experienced in the design of girder bridges. Workshop experience desirable. Salary range : £1015–£1065.

Travel concessions, holidays with pay, prospects of promotion and permanency, membership of superannuation fund.

Apply, stating age, previous experience, &c., to Chief Civil Engineer, B.R. Western Region, Paddington Station, W.2. E8198

PUBLIC APPOINTMENTS

GHANA PUBLIC SERVICE COMMISSION

APPOINTMENTS

Applications are invited for the following vacancies in the GHANA RAILWAY :

ASSISTANT WORKS MANAGER.—To assist the Works Manager in maintaining heavy workshop repairs to locomotives, cranes, auxiliary plant and other mechanical equipment. Candidates must hold a B.Sc. (Eng.) or other recognised engineering degree and must have not less than 2 years' practical post-graduate experience, or being not less than 23 years of age, must have passed Parts I and II of the examination of the Institution of Mechanical Engineers. Salary in range £1080–£2080 a year.

CARRIAGE AND WAGON SUPERINTENDENT.—To be responsible to the Chief Mechanical Engineer for the maintenance and repair of carriages and wagons. Candidates who must not be less than 35 years nor more than 50 years old, must (i) have had regular training in the design, maintenance and repair of carriages and wagons ; and (ii) have had at least 5 years' administrative experience in the Carriage and Wagon Section of a reputable railway. A knowledge of saw-milling and saw-doctoring would be an advantage. Salary in range £1770–£1970 a year according to experience.

Appointments on contract for two tours each of 18–24 months duration. Gratuity at rate of £12 10s. for each completed month of residential service payable on completion of contract. Outfit allowance £30–£60 on first appointment. Free first class passages for officer, wife and up to 3 children under 18 years and in addition an education allowance for children when not resident in Ghana of £100 a child for up to 3 children under 18 years. Generous home leave on full pay. Income tax at low local rates. Preservation of superannuation or pension rights, where applicable, can be arranged.

For further particulars and application form, write, stating age, qualifications and experience to THE DIRECTOR OF RECRUITMENT, GHANA HIGH COMMISSIONERS' OFFICE, 13, BELGRAVE SQUARE, LONDON, S.W.1. E8243

STAFFORDSHIRE POTTERIES WATER BOARD

CLERK OF WORKS

The Board invite applications from suitable candidates for the position of CLERK OF WORKS on the construction of a 2,000,000-gallon reinforced concrete reservoir, an 18in. washout main and other ancillary works, at a salary of £12 per week, plus £3 per week subsistence allowance.

It is estimated that the time required for the completion of this contract will be approximately eighteen months, and at the end of this time it is anticipated that further works will be under construction.

Applications, stating age, full details of experience, accompanied by copies of two recent testimonials, and endorsed "Clerk of Works," must reach the undersigned not later than Monday, 25th August, 1958.

Canvassing in any form will be deemed a disqualification.

C. V. BROWN,
M.I.C.E., M.I.Mech.E., M.I.W.E.,
Engineer and Manager and Clerk.

Albion Street,
Hanley,
Stoke-on-Trent. E8246

MERSEY RIVER BOARD

ASSISTANT ENGINEER

Applications are invited for the position of ASSISTANT ENGINEER at the Board's Office in Sale, Cheshire.

The salary will be in accordance with Local Government Scales, within the range A.P.T. Grade I to Special Grade (£575–£1030 per annum), according to qualifications and experience. Candidates should have passed Parts I and II of the Institution of Civil Engineers Examination or hold a University Degree exempting them.

The appointment, which may be terminated by one month's notice on either side, is subject to the Local Government Superannuation Acts and to the passing of a medical examination.

Applications, stating age, education, qualifications and experience, together with the names of two persons to whom reference may be made, should be addressed to J. T. Firth, B.Eng., M.I.C.E., Engineer to the Board, at the address given below, and should be received not later than 29th August, 1958.

A. H. JOLLIFFE,
Clerk of the Board.

Liverpool Road,
Great Sankey,
Warrington. E8197

GOVERNMENT OF FIJI

PUBLIC WORKS DEPARTMENT

ASSISTANT ENGINEER (MECHANICAL)

To undertake machine shop maintenance, inspect boilers, and occasional marine jobbing.

Permanent and pensionable appointment or on contract for three years with gratuity of 15 per cent of basic salary on satisfactory completion of engagement. Salary range £982 to £1800 p.a. Free passages for officer, wife and family up to cost of four adult passages. Quarters for married officers, bachelors accommodated in Government Mess. Generous home leave. Income tax at local rates.

Candidates, not over 45, should hold a M.O.T. 1st Class Marine Engineer's Certificate with steam and diesel endorsements.

Write Director of Recruitment, Colonial Office, London, S.W.1, stating briefly age, qualifications and experience, quoting BCD 112/49/07. E8239

PUBLIC APPOINTMENTS

A.E.R.E.
HARWELL

7 GeV PROTON
SYNCHROTRON

PROFESSIONAL ENGINEER

A Professional Engineer (A.M.I.E.E. normal minimum), with relevant experience, is required to be responsible for the maintenance and operation of all electrical plant and equipment associated with the project, including two 60MVA motor alternator sets feeding about 30/sec. D.C. pulses to a 7000-ton electromagnet. There will be a 15 MeV linear accelerator supplied by R.F. power at about 115 Mc/sec. and a control room with extensive monitoring facilities.

Salary : £1790-£2080.

Send POST CARD to the Group Recruitment Officer (1180/25), U.K.A.E.A., Atomic Energy Research Establishment, Didcot, Berks, for details and application form.

E8214

STRUCTURAL ENGINEERING DRAUGHTSMEN

required by

MINISTRY OF WORKS

for employment in London, Scotland and Provinces on design and detailing of reinforced concrete or structural steelwork.

SALARY RANGE £550 (age 21) to £870 p.a., London (slightly less elsewhere). 5-DAY WEEK. 3½ WEEKS' ANNUAL LEAVE INITIALLY.

STARTING PAY ACCORDING TO AGE, QUALIFICATIONS AND EXPERIENCE.

GOOD PROSPECTS OF PROMOTION WITH SALARIES OF £1015 p.a. AND ABOVE.

OPPORTUNITIES FOR PERMANENT POSTS LEADING TO PENSIONS (NON-CONTRIBUTORY).

Possession of O.N.C. or equivalent an advantage.
Interviews at Regional Offices where possible.

APPLICATIONS.—State age, training and experience to Chief Structural Engineer, Ministry of Works, Room 404, Abell House, John Islip Street, S.W.1.

E7717

ENGINEERS, CHEMISTS AND PHYSICISTS

are required by

THE UNITED KINGDOM ATOMIC ENERGY AUTHORITY

(Industrial Group)
DOUNREAY EXPERIMENTAL REACTOR ESTABLISHMENT
Thurso, Caithness, Scotland,
to act as :

REACTOR SHIFT MANAGER

who will be responsible, as senior shift officers, to the Reactor Operations Manager for the safe and efficient operation of a reactor to an agreed programme. This will involve control of all operational activities associated with the reactor. (Ref. 2500).

The materials testing reactor is now in operation and construction of the experimental power-breeder reactor is nearing completion.

These appointments offer excellent opportunities for the acquisition of experience in the problems of operation of nuclear reactors and their auxiliaries, and may lead to further managerial responsibility in this field for suitable men.

Applicants must possess an honours degree in chemistry or physics, or be corporate members of a senior engineering institution, or hold equivalent qualifications. They should have held responsible posts in industry which involved the supervision of labour.

Salary will be assessed within the scale
£1300—£1740

YOUNG ENGINEERS AND PHYSICISTS:

who wish to make their careers in reactor operation or technology, are also required to join teams of engineers and scientists engaged in the operation and utilisation of the reactors, or on experimental critical assemblies of reactor systems. (Ref. 2501).

Applicants must possess an honours degree in engineering or physics, or be corporate members of a senior engineering institution, or have equivalent qualifications.

Experience in control of labour would be an advantage for some of the appointments.

Salary will be assessed within the scale
£815—£1270

There is considerable scope for advancement to posts with a salary scale of £1300—£1740.

Contributory Pension Scheme.

Housing at Thurso or hostel accommodation may be available. Substantial assistance towards removal expenses is given in certain cases.

Send postcard for application form, quoting appropriate reference to Establishments Officer, D.E.R.E., Dounreay.

Closing Dates : 25th August, 1958

E8201

TENDERS

KINGDOM OF THAILAND

ROYAL IRRIGATION DEPARTMENT, BANGKOK, THAILAND

HYDRAULIC TURBINES

The Royal Irrigation Department of the Kingdom of Thailand requests sealed, written BIDS for FURNISHING and DELIVERING c.i.f. Bangkok Wharf for the Yanhee Multipurpose Project, Kingdom of Thailand, in accordance with the Contract Documents, including Invitation for Bids—No. YS–2–3, the following equipment :—

TWO 98,350 metric h.p. Francis type, Vertical-Shaft, 150 r.p.m. HYDRAULIC TURBINES, rated at a net effective head of 100 metres, complete with governors and pertinent equipment.

Bids will be opened at 10.00 a.m., 30 October, 1958. Copies of Contract Documents, including Invitation for Bids—No. YS–2–3, may be obtained by qualified bidders on written request on bidder's letterhead, addressed to Royal Irrigation Department, Attention : Thai Liaison Engineer, c/o Engineering Consultants, Inc., 1940, West Mississippi Avenue, Denver, 23, Colorado, U.S.A. Each request must be accompanied by a cheque or money order, payable to the Royal Irrigation Department, in the amount of U.S. $5.00 for each copy of the Contract Documents requested.

M. L. XUJATI KAMBHU,
Director General,
E8244 Royal Irrigation Department.

PENZANCE CORPORATION WATERWORKS

DRIFT SCHEME

LOWER DRIFT RESERVOIR

The Corporation will be shortly inviting TENDERS from a selected list of contractors for the construction of an impounding reservoir of 300 m.g. capacity at Lower Drift, Penzance, Cornwall. The contract involves the construction of a concrete gravity dam 470 feet long and 50 feet high, and ancillary works.

Contractors experienced in this work are invited to submit their names to the undersigned by Monday, 18th August together with a list and particulars of similar works they have carried out since 1945.

A list of selected contractors to be invited to tender for the works will be prepared in conjunction with the Corporation's Consulting Engineers, Messrs. Herbert Lapworth Partners. It is intended that work should be commenced later this year.

E. O. WHEALE,
Town Clerk.

Municipal Buildings,
Penzance. E8148

TENDERS

MERE AND TISBURY RURAL DISTRICT COUNCIL

COMPREHENSIVE SCHEME OF WATER SUPPLY—PART IV. CONTRACT NO. 3

The Council invite TENDERS, on a fixed price basis, from Civil Engineering Contractors experienced in similar work, for the CONSTRUCTION OF WATER RETAINING STRUCTURES, comprising Five Concrete Reservoirs, a Break Pressure Tank and Alterations to an Existing Reservoir of Brick Construction, together with ancillary works, as under.

(a) Hindon Reservoir—65,000 gallons capacity.
(b) Milton Reservoir—150,000 gallons capacity.
(c) Hatch Reservoir—30,000 gallons capacity.
(d) Donhead Reservoir—140,000 gallons capacity.
(e) Tollard Royal Reservoir—20,000 gallons capacity.
(f) Donhead Break Pressure Tank—2000 gallons capacity.
(g) Berwick Reservoir—alterations to roof.

Contractors desirous of Tendering are requested to send their names and addresses to the Council's Consulting Engineers, Messrs. T. Ward Whitfield and Son, 54, Stallard Street, Trowbridge, Wilts., accompanied by a cheque for five guineas, made payable to the Council, not later than 22nd August, 1958, after which general conditions of contract, specification, bills of quantities and form of Tender will be forwarded. The deposit cheque will be returned, after the contract is let, on receipt of a bona fide Tender and the return of all documents.

Tenders, in plain, sealed envelopes, endorsed "Tender for Comprehensive Water Supply Scheme—Part IV—Contract No. 3," must reach the undersigned not later than the date that will be specified by the Engineers.

The Council does not bind itself to accept the lowest or any Tender.

M. E. BARRETT,
Clerk to the Council.

Council Offices,
Mere,
Wilts. E8203

KINGDOM OF THAILAND

ROYAL IRRIGATION DEPARTMENT, BANGKOK, THAILAND

STEEL REINFORCEMENT BARS

The Royal Irrigation Department of the Kingdom of Thailand requests sealed, written BIDS for FURNISHING and DELIVERING c.i.f. Bangkok Wharf for the Yanhee Multipurpose Project, Kingdom of Thailand, in accordance with the Contract Documents, including Invitation for Bids—No. YS-4-2, the following equipment :—

2100 metric tons of STEEL REINFORCEMENT BARS, sizes 3 to 11 inclusive, in lengths of approximately 12 metres.

Bids will be opened at 10.00 a.m., 18 September, 1958. Copies of Contract Documents, including Invitation for Bids—No. YS-4-2, may be obtained by qualified bidders, without cost, on written request on bidder's letterhead, addressed to Royal Irrigation Department, Attention : Thai Liaison Engineer, c/o Engineering Consultants, Inc., 1940, West Mississippi Avenue, Denver, 23, Colorado, U.S.A.

M. L. XUJATI KAMBHU,
Director General,
E8245 Royal Irrigation Department.

STATE ELECTRICITY COMMISSION OF VICTORIA

AUSTRALIA

22, WILLIAM STREET, MELBOURNE, VICTORIA, AUSTRALIA

The Commission is inviting TENDERS for MOVABLE COAL CONVEYOR DRIVE AND TAKE UP UNITS, Morwell Project, in accordance with Specification No. 58–59/23.

Full particulars are available at the above address and from the Agent-General for Victoria, Victoria House, Melbourne Place, Strand, London, W.C.2.

Tenders, endorsed "Tender to Specification No. 58–59/23," are returnable direct to the Commission at the above address on or before 11 a.m. on 3rd September, 1958.

The Commission does not bind itself to accept the lowest or any Tender. E8158

EDUCATIONAL

TECHNICAL HOME STUDY COURSES

For A.M.I.Mech.E., A.M.I.Chem.E., A.M.I.M.I., A.F.R.Ae.S., C. & G., &c.

OVER 50 FIRST PLACES and more than 2000 Passes have been secured by T.I.G.B. Students at Professional Engineering Examinations. We have a wide range of exclusive Home Study Courses in all branches of Engineering—Mechanical, Electrical, Aeronautical, Automobile, Chemical, Gas, Radio, and Television, Draughtsmanship, &c. Textbooks, blueprints, &c., are provided and, if desired, fees may be paid by moderate instalments.—Write (stating subject of interest) for copy of 110-page Prospectus FREE and without obligation.

THE TECHNOLOGICAL INSTITUTE OF GREAT BRITAIN
(Dept. 76),
29, WRIGHT'S LANE, LONDON, W.8.
E102 E

A.M.I.MECH.E., B.Sc., City and Guilds, &c. Guarantee Postal Courses for all Exams., and Technical Divisions from Elementary to Degree standard. Approximately 95 per cent. successes. 144-page prospectus free on request.—B.I.E.T. (Dept. 22), 29, Wright's Lane, London, W.8. E114 E

EDUCATIONAL

CITY OF LEICESTER EDUCATION COMMITTEE

COLLEGE OF TECHNOLOGY AND COMMERCE

SCHOOL OF COMMERCE

WORK STUDY RESIDENTIAL COURSES, 1958/9

TEN-WEEK WORK STUDY TRAINING COURSE.— The College is one of the establishments originally selected for the national scheme for training Work Study practitioners. Courses commencing next September, January, April.

WORK STUDY APPRECIATION COURSE (ONE WEEK) : on such topics as Ergonomics, Work Sampling, P.M.T.S., Operation Research, Organisation and Method, &c. Courses in November, March, June. Also, short residential courses in GENERAL FOREMANSHIP (3 weeks), MIDDLE MANAGEMENT (one week), and a "SANDWICH" COURSE IN MANAGEMENT STUDIES for management trainees and others with management potential.

Further details from the Head of the School of Commerce, College of Technology and Commerce, Leicester. E8241 E

NOTICE

UNIVERSITY OF MANCHESTER

The next SESSION COMMENCES on THURSDAY, 2nd OCTOBER, 1958.

E8251 E

SITUATIONS VACANT

APPLICANTS ARE ADVISED TO SEND COPIES, NOT ORIGINALS, OF THEIR TESTIMONIALS UNLESS OTHERWISE REQUESTED.

APPLICATIONS ARE INVITED FROM ENGINEERS for responsible posts in the following fields :

Machining and Pressworking Processes.
Design and Development of Machine Tools.
Automation of Production and Inspection Processes (a knowledge of work study techniques would be advantageous).
Vibration and Servo-Mechanisms.

Excellent opportunities for those with ability and initiative. Candidates should have a degree, Higher National Certificate or equivalent qualification.—Send full details including age, qualifications, experience and present salary in confidence to BOX No. E8107, "The Engineer." A

APPLICATIONS are invited for a position as ASSISTANT ENGINEER in the "Special Service" Section of the Engineering Department, Eagle Star Insurance Co., Ltd., 15/25, Ewell Road, Cheam, Surrey. Candidates should be between 28–32 years, having served a full apprenticeship with a Higher National Certificate, and be experienced in the design of pressure vessels and structures, also conversant with modern methods of fabrication. Commencing salary £850. Non-contributory pension and contributory widows' pension.—Apply in own handwriting, giving age, training and experience, to the CHIEF ENGINEER at CHEAM. E8222 A

APPRENTICE SUPERVISOR

HILGER & WATTS, LTD., makers of scientific instruments, invite applications for the post Apprentice Supervisor for their two London factories. The successful applicant will be expected to act as Instructor in the Basic Workshop Training School which is being opened in the Autumn, and to assist generally in the training and supervision of craft apprentices and technical apprentices during the time they are in the Shops.

Qualifications required are an engineering background at least to H.N.C. level, experience in instructing and some knowledge of precision engineering.

The post is a new one and offers considerable scope to a man with the right experience and background.

Applications to :
The Chief Personnel Manager,
98, St. Pancras Way,
LONDON, N.W.1.
E8206 A

BEARING SPECIALIST required by the Owen Organisation, to develop sales of recently established bearing alloy. Initially based in Bristol to cover South-west England and South Wales. Enthusiasm and energy required with good opportunities for advancement to Sales Manager leading team similar to the first appointment. Primary requirements are a sound engineering knowledge of bearings of all types other than ball and roller, together with ability to deal with problems in the field. Age group suggested is under 40. Remuneration according to ability and experience but above £1000 per annum, plus commission and expenses. A superannuation scheme is in existence.—Apply, giving full particulars, to the Director and General Manager, C. and L. Hill, Limited, Stringes Lane, Willenhall, Staffs. E2021 A

SITUATIONS VACANT

ASSISTANT MANAGER required by coal distributors eventually to assume full responsibility for operation of company's wharves. Engineering knowledge of all types of wharf plant and road transport essential, preferably with drawing-office experience. Age no barrier, but under 40 preferred.—Communicate in strict confidence, indicating salary required, to BOX No. E2029, "The Engineer." A

BRITISH PETROLEUM COMPANY, LTD., has a vacancy for a MECHANICAL ENGINEER at its Head Office in London, for duties concerned with technical aspects of industrial lubrication. Applicants, aged 30–40, should possess a University Degree or A.M.I.Mech.E., and have had experience of metal cutting and forming, and general industrial lubrication. Salary according to age, qualifications and experience. Non-contributory pension fund. Assisted house purchase scheme ; removal expenses and settling-in allowance payable in certain cases ; luncheon club.—Write, giving full particulars, quoting reference H.4511, to BOX 5800, c/o 191, Gresham House, E.C.2. E8225 A

CIVIL ENGINEERS with experience wanted for design work in London Office in connection with Strathfarrar and Kilmorack Hydro-Electric Scheme, Scotland. Staff pension scheme. Five-day week.—Apply Sir William Halcrow and Partners, Stanhope House, 47, Park Lane, London, W.1. Tel No. : Grosvenor 8171. E8163 A

CIVIL ENGINEERING ESTIMATOR required for the Newport, South Wales Office of Railway and Civil Engineering Contractors.

Applicants should have a wide experience of tendering for Civil Engineering Contracts and a knowledge of Railway Engineering and Estimating would be considered an advantage.

The appointment offers the successful applicant excellent prospects in an expanding Company.

Applications which will be treated in the strictest confidence, should state age, qualifications, experience in detail, and indication of the salary required.

Write—ISCA FOUNDRY COMPANY, LTD., Newport, Mon. E8157 A

COMBUSTION ENGINEER

COURTAULDS, LIMITED, require an ENGINEER for their Engineering Headquarters, Coventry, to work in a specialised section on specification, selection and starting up of new boiler plants ; the section is also responsible for investigating, testing and advising on the use of existing boilers and their auxiliaries.

A sound basic knowledge of modern steam raising practices is essential, and experience of coal firing on chain-grate stokers is advantageous.

Optimum age 40.

Candidates should write for a detailed form of application to the Director of Personnel, COURTAULDS, LIMITED, 16, St. Martin's le Grand, London, E.C.1., quoting reference number B.31. E8143 A

COMPANY OPERATING A MODERN CONTINUOUS CHEMICAL PLANT invites applications for the post of

DEPUTY WORKS ENGINEER.

Applicants should preferably be in the age range of 40–50, with mechanical engineering qualifications and experience. They must have energy, shop floor experience and a down to earth attitude, realising that organisation and administration exists only to get things done and are not ends in themselves. Experience of chemical plant or refinery installation with continuous highly instrumented process plant where scheduled maintenance methods are in operation would be an advantage.

The post is permanent and offers an interesting career in agreeable surroundings.

Excellent terms of employment, including pension scheme.

Applications, giving full particulars, including age, experience and qualifications, should be addressed.—BOX No. E8210, "The Engineer." A

DRAUGHTSMAN REQUIRED by Materials Handling Engineers with offices in Surbiton. Age 23–28, experience in ore handling and quarry plant and structural knowledge. Apply.—BOX No. E2025, "The Engineer." A

DRAUGHTSMAN, SENIOR. Experienced in coal handling, screening and general structural plant, required by Group of South Coast Companies with headquarters at Portsmouth. Staff pension scheme in operation. Apply, stating age, experience and salary required.—BOX No. E2026, "The Engineer." A

DRAUGHTSMEN.—Vacancies exist for the following :—

1. GENERAL ENGINEERING DRAUGHTSMEN (Senior), having experience in machine design and works layouts. A knowledge of works building design desirable, but not essential. Technical education to at least O.N.C. Ref. : 2444/1.
2. JIG AND TOOL DRAUGHTSMEN (Senior). A knowledge of general engineering and machine design advantageous, but not essential. Technical education to at least O.N.C. Ref. : 2444/2.

Some assistance will be given with regard to house purchase in cases of successful applicants who are married.

Write, giving details of experience and stating age and present salary, to the Personnel Manager, Ferodo, Limited, Chapel-en-le-Frith, Via Stockport. E8224 A

DRAUGHTSMEN, Experienced, detailing Steel structures ; bins, etc. Knowledge design advantage. Salary according ability up to 33½ per cent above A.E.S.D. Pension Scheme optional.—Write in confidence : Crabtree, Davey, Fifer, Consultants, 72a, Malden Road, New Malden, Surrey. E2033 A

ENGINEERING DRAUGHTSMAN.—Technical Assistant required by large London Institution, to be concerned with the design and layout of Oil-fired Boiler Plant and Services as occasioned by extensive development programme. Minimum qualifications H.N.C. Practical experience essential, with appreciation of planned maintenance technique. This is an exceptional opportunity for individual expression and an enthusiasm for interesting and varied work is a most necessary requirement. Salary range £800–£1000 per annum.—Write to BOX No. 1881, c/o Charles Barker and Sons, Ltd., Gateway House, London, E.C.4. E8205 A

SITUATIONS VACANT

ENGINEER (MECHANICAL).—Applications are invited from Engineers, not over 35 years, who possess First Class M.O.T. Certificates (Steam). Willing to reside in or near London for duties in that area and to undertake three-monthly tours of inspections of boilers, pressure vessels, &c., in West Africa. Salary in accordance with age, previous experience, if any, plus expenses and allowances. Non-contributory pension scheme.—Apply in own handwriting to BOX No. E8227, "The Engineer." A

ENGINEER SURVEYOR required for inspection of Boiler and Pressure Plant. Must have 1st Class M.O.T. Certificate with Steam Endorsement or equivalent. Salary £735 to £1060 (E.S.A. Scale) ; other benefits. N. London area.—Apply, Engineering Dept., GENERAL ASSURANCE CORP., LTD., 99, Aldwych, W.C.2. E8204 A

ENGINEERS AND DRAUGHTSMEN

TECHNICAL ESTIMATORS required for centrifugal pump department, large, progressive company in South of England. Pension scheme. Reply, giving age, qualifications and salary required.—BOX No. E2023, "The Engineer." A

ENGINEERS—VENEZUELA

TWO MECHANICAL ENGINEERS, of minimum age 35, sought for 100,000kW steam power station in Venezuela. Qualifications required are :

Higher National Certificate, University Degree or Corporate Membership of Institution of Mechanical Engineers.

At least five years of operating and maintenance experience in a responsible position with a steam generating plant of 50,000kV or higher.

Salary, paid in U.S. dollars, will be on a generous scale.

Full details should be forwarded by post and time will be allowed for overseas applications to be received and considered.—Write to Messrs. Mackness and Shipley, Parliament Mansions, Abbey Orchard Street, London, S.W.1.

E8221 A

FAST-MOVING, MEDIUM-SIZED ENGINEERING COMPANY requires an ASSISTANT TO CHIEF ENGINEER. Essential that applicants have knowledge of design drafting, but the position will emphasise the organisational aspect of the engineering function as a part of company management. The company is prepared to train a man with the necessary personal attributes—ability to think, resourcefulness and energy.—Apply in writing to Matthias Spencer and Sons, Ltd., Arley Street, Sheffield, 2. E8220 A

GLACIER METAL CO., LTD. ENGINEERING MANAGEMENT

Qualified and experienced SENIOR PRODUCTION ENGINEER required to control and develop full range of production engineering activities in factory Production Unit manufacturing plain bearings and centrifugal oil filters.

Engineering Degree and/or membership of I.Mech.E. or I.Prod.E. are preferred qualifications with wide experience of production engineering in all its aspects.

Starting salary £1000/£1200 per annum, with excellent prospects for further advancement. Modern factory situation close to Ayrshire coast.

Brief particulars of qualifications, experience and present salary to Personnel Manager, GLACIER METAL COMPANY, LTD., KILMARNOCK, AYRSHIRE.

E8248 A

HEATING INTERMEDIATE DRAUGHTSMAN required in London accustomed to design with minimum supervision. Salary up to £1000 per annum to right man. Permanent position with pension facilities and excellent prospects.—Write in confidence, stating full details of age, experience and past employers to Ellis (Kensington), Ltd., Kendrick Place, London, S.W.7. E2001 A

INSTRUMENT SUPERVISOR required to supervise a small team of instrument mechanics, which is expanding to meet modern requirements essentially on the maintenance/control as applied to modern industry. Also to prepare layout equipment, estimate and specify for new installations. Technical qualifications and experience to cover mechanics, pneumatics, electrics and electronics.—Applications should give full details of experience, age, etc. to BOX No. E2031, "The Engineer." A

METALLURGICAL ENGINEER required by organisation in Leicestershire. Successful applicant will be required to advise on metallurgical problems and preferably finishing processes including plating, polishing and painting, &c. Duties will include occasional visits to engineering firms throughout the country. Membership of professional institution and ability to work on own initiative essential. Good salary and superannuation under F.S.S.U.—Send full details including age, qualifications, experience, and present salary in confidence.—BOX No. E8161, "The Engineer." A

MUNICIPAL MUTUAL INSURANCE LIMITED has vacancies for ENGINEER SURVEYORS in Birmingham and London. Posts are pensionable and permanent to satisfactory candidates, who should have served an apprenticeship and have sound practical and theoretical knowledge. Technical qualifications : First Class Ministry of Transport Certificate. Salary : £735–£1060 per annum.—Apply in own handwriting, marking the envelope "Application : Engineer Surveyor," and "Private and Confidential," to the Chief Engineer, 22, Old Queen Street, Westminster, S.W.1. E8208 A

MUNICIPAL MUTUAL INSURANCE LIMITED has a vacancy for a CRANE AND LIFTING GEAR SURVEYOR, preferably with Higher National Certificate, in London. Post is permanent and pensionable to satisfactory candidate, who should have served an apprenticeship and have sound practical and theoretical knowledge of cranes and lifting gear. Salary : £735–£1060 per annum.—Apply in own handwriting, marking the envelope "Private and Confidential," to the Chief Engineer, 22, Old Queen Street, Westminster, S.W.1. E8209 A

Classified Advts. continued on page 102

SITUATIONS VACANT

MECHANICAL DRAUGHTSMAN

Mechanical Draughtsman required for interesting project work in the Food Industry. This appointment will provide opportunity for ambitious young Engineer to progress and widen his experience. Some travelling to sites may be involved from London base. Preference will be given to candidates who have attained H.N.C. or the equivalent standard. Salary according to age and experience. Write to P.O. —BOX No. E2020, "The Engineer." A

ONE ASSISTANT MECHANICAL AND ELECTRICAL ENGINEER required for Plant operation and maintenance on Nauru or Ocean Island, Central Pacific. Salary £975 p.a. Australian Currency plus qualification and child allowance where applicable. Free housing, partly furnished, and free board or allowance in lieu thereof. No income tax payable. Qualifications—Under 30 years of age, standard required up to G.I.Mech.E. or equivalent. Term of service 3½ years with intermediate leave after 21 months. Apply THE BRITISH PHOSPHATE COMMISSIONERS, 2, Grosvenor Gardens, London, S.W.1, enclosing full particulars of experience and education. E8233 A

PLANT ENGINEER, with mechanical, electrical and structural experience, for Birmingham area. Applicants should have knowledge of layout and construction of plant, factory extensions and general machinery maintenance. Pension scheme.—Applications, stating age, with full details of experience and indicating salary range, to BOX No. E2028, "The Engineer." A

PREVENTATIVE MAINTENANCE

A qualified, time-served, MECHANICAL ENGINEER is required for the London Office of a nationally-known Food Manufacturing Group to assist the Chief Engineer in the introduction of a system of Preventative Maintenance in factories throughout the United Kingdom. Preference will be given to candidates who hold the minimum qualification, H.N.C. Mechanical Engineering, or equivalent, and can show proof of successful work in Preventative Maintenance. State age, qualifications, experience and salary expected. Write to P.O. —BOX No. E2019, "The Engineer." A

PRODUCTION ENGINEER required for Light Engineering Company. South-west Middlesex area. Duties will involve preproduction development of new instruments to be produced in large quantities and of a competitive nature. Experience of modern techniques and design essential. Applicants must have sound engineering knowledge, with Higher National Certificate or equivalent. This post offers excellent opportunities and is pensionable. Write, stating full details of previous experience, age and salary required.—BOX No. E8193, "The Engineer." A

REINFORCED CONCRETE DRAUGHTSMAN required preferably with civil engineering bias for work in Consulting Engineers' office. 5-day week and bonus to suitable applicants.—Apply T. F. BURNS & PARTNERS, 25, Victoria Street, S.W.1. Telephone ABBey 4140 for appointment. E2032 A

RICHARDSONS, WESTGARTH & CO., LIMITED.
DRAUGHTSMEN

There are vacancies at Wallsend in an expanding department working on a new range of heavy engineering equipment.

Experience of power station layout, boilers, turbines, heat exchangers or similar equipment would be an advantage.

Conditions of employment are good. Excellent opportunities for advancement for men with high technical ability and initiative.

Write, in confidence to the Group Personnel Officer, RICHARDSONS, WESTGARTH & CO., LIMITED, P.O. Box No. 2 Northumberland Engine Works, Wallsend.

E8231 A

SALES REPRESENTATIVE required, London area, operating Victoria Street office, dealing engineering plant for chemical and mechanical industries, marine engineering experience advantage. Exceptional opportunity for ambitious and live engineer. Salary, expenses, plus commission, car provided.—BOX No. E2030, "The Engineer." A

SECTION SAFETY OFFICER is required to run the Safety Department of a medium-sized integrated Iron and Steel Plant employing 3200. Knowledge and experience of safety matters in heavy industry and civil defence would be an advantage. Salary commensurate with the great importance attached to accident prevention at this Plant.—Forms of application are available from The Labour Officer, RICHARD THOMAS AND BALDWINS, LTD., P.O. Box No. 7, Redbourn Works, Scunthorpe, Lincs. E8144 A

STEAM ENGINEER required for boiler-house control, steam distribution and services. Experience in running water-tube boilers and ancillary equipment essential. B.O.T. or M.O.T. Certificate. Age 28/40. Contributory pensions scheme.

Apply: Personnel Manager,
THE MIDLAND TAR DISTILLERS, LTD.,
OLDBURY, Near Birmingham.

E8223 A

STEEL WORKS CRANES.—An old-established crane manufacturer with Head Office and factory in the North of England, seeks the services of a DESIGN DRAUGHTSMAN with sound experience of overhead electric travelling cranes to B.I.S.R.A. Specification. This opportunity offers scope and unique prospects to a first-class man with initiative, to whom a good salary will be paid. Applications, which will be treated with absolute confidence, should give details of experience, with age and salary required, and be addressed to the Managing Director.—BOX No. E2022, "The Engineer." A

WEST MIDDLESEX FIRM require immediately a competent ENGINEERING DRAUGHTSMAN, fully experienced in design of electro-mechanical devices.—BOX No. E136, "The Engineer." A

MECHANICAL ENGINEER

aged about 35, required to take charge of the development of large Industrial Gas Turbines. Applicants should have considerable practical experience in this field, and should preferably have a degree or equivalent.

Applications, which will be treated in confidence if requested, should be made in writing, stating personal particulars and experience, to Personnel Manager, C. A. Parsons & Co., Ltd., Heaton Works, Newcastle upon Tyne, 6.

E8229 A

MSL

have been retained to advise on the appointment of a

SALES MANAGER

to a north country company manufacturing specialised machine tools in demand throughout the engineering industry.

The Sales Manager will be responsible for the development of potential markets personally, both in this country and through agents and merchants abroad, and for all aspects of sales administration.

Applicants must be qualified to at least H.N.C. standard and should have had not less than 5 years' experience in the selling of machine tools or special purpose machinery.

Initial salary not less than £1,500 with prospects of promotion to board level. A pension scheme is in operation and a car will be provided.

Preferred age range 35 to 45.

No information will be disclosed to our clients until candidates know their identity and have given permission after personal discussion. Please send brief details in confidence, quoting reference G.1154, to G. K. Dickinson.

MANAGEMENT SELECTION LIMITED
17, Stratton Street, London, W.1.

E134 A

THE GENERAL ELECTRIC COMPANY LIMITED

have vacancy for an

OPERATING ENGINEER

for their Power Plant Division based at Erith, Kent.

Duties include the commissioning and operation of turbo-alternator and turbo-blower plant at home and abroad and the site investigation of operating problems.

Applicants must possess initiative and determination and the post would suit a Shift Charge Engineer in a large central power station. Minimum qualification Higher National Certificate.

Apply giving age and experience to Personnel Manager (FLT), The General Electric Company, Limited, Erith, Kent.

E8202 A

WELDING ENGINEER

required to control site welding of large oil storage tanks. Must be conversant with modern welding techniques. Position incorporates non-contributory pension scheme. Apply, stating age and qualifications, to BOX No. E8190, "The Engineer." A

R. S. T.

A large copper mine in the Rhodesian Selection Trust Group requires a

SENIOR ELECTRICAL ENGINEER
in NORTHERN RHODESIA.

Applicants should hold a degree in Electrical Engineering and have had subsequent experience in heavy engineering work. They should preferably be under 35 years of age.

Duties will consist of planning engineering projects of a varied nature in connection with large-scale mining operations, including power generation and distribution, mine shafts and haulage, ore treatment, smelting and other associated heavy engineering plant.

Starting salary would be commensurate with qualifications and experience. In addition there are generous cost-of-living, bonus, pension, life assurance and medical schemes.

The employee's outward passage expenses to Rhodesia would be paid. Leave at 51 days p.a. may be accumulated up to 153 days.

Applicants should send full particulars of age, qualifications and experience, to :—
Overseas Personnel Officer, Selection Trust Limited, Mason's Avenue, Coleman Street, London, E.C.2, QUOTING R.2/E.

E8194 A

SHELL

"SHELL" RESEARCH LIMITED

require

RESEARCH ENGINEERS

with a University honours degree or equivalent qualification in Mechanical Engineering at

THORNTON RESEARCH CENTRE

near Chester, for research and development work on oil products. The successful applicants, who should preferably have some research experience and not be over 30 years of age, will be required to co-operate with research chemists and physicists in the development of oil products. The work will also involve the planning, organisation and conduct of test programmes designed to evaluate the performance of these products in engines in the laboratory and in vehicles undergoing field trials.

Previous experience on testing and development work with I.C. engines would be valuable, and there are excellent opportunities for advancement within our organisation for the right people with a flair for research.

Salary and prospects are good, we have a five-day working week, and there is an excellent pension scheme. If necessary, help with house purchase and removal costs from an established home can be provided for successful applicants.

Applications should be addressed to:—
"SHELL" RESEARCH LIMITED,
STAFF DEPARTMENT (R),
16, FINSBURY CIRCUS, LONDON, E.C.2.

E8192 A

DESIGNER/DRAUGHTSMEN, MECHANICAL

are required by MICHELIN TYRE CO., LTD., for interesting work on Plant Development at their Stoke-on-Trent Factory.
Opportunities also exist at Stoke for work on the erection and equipment of a new factory at Burnley.
Qualifications required are :
Age, not under 25. Sound apprenticeship.
H.N.C. in Mechanical Engineering.
Good design experience in one of :
(a) Works services, involving steam, pneumatic and hydraulic pipework.
Space heating and ventilating.
(For this, a Heat Engines or Thermodynamics endorsement is desirable.)
(b) Layout and installation of medium to heavy mechanical handling plant.
Roller, belt and chain conveyors.
(c) General mechanical work and process plant layout.
Appointments are permanent and pensionable.
Salaries £850–£950 p.a. for 5-day, 40-hour week.
ASSISTANCE WITH HOUSING WHERE NECESSARY.
Excellent canteen, sports and welfare facilities.

Please write for application form to :
MICHELIN TYRE CO. LTD.,
(SPA DEPT.), STOKE-ON-TRENT, STAFFS.
quoting reference DD/10/E.

E8146 A

CHIEF INSPECTOR REQUIRED

to administer the company's policy for the quality control of precision machine tool manufacture. A good knowledge of metrology essential, with particular regard to gearing and allied subjects.—Write, with full details of past experience, &c., to :

The Secretary, W. E. SYKES LIMITED, Staines, Middlesex.

E8230 A

SITUATIONS VACANT

BTR

require a

SALES ENGINEER

for

VIBRO INSULATORS

specialising in

MARINE APPLICATIONS

Preference will be given to candidates with experience and contacts in

MARINE ENGINEERING

also some knowledge of mounting and shock absorption systems for VIBRATION AND NOISE SUPPRESSION.

Good salary and prospects : Pension : Car : Expenses.

Send details of education and experience, &c., marked "confidential" to :

Group Personnel Officer (Ref. VI)
B.T.R. INDUSTRIES LTD.
Herga House, Vincent Square,
London, S.W.1. E8196 A

SITUATIONS VACANT

PROJECT ENGINEERS

—SENIOR AND JUNIOR—

required by an expanding chemical engineering organisation, to be responsible for the overall execution of projects from early negotiations to commissioning. Mechanical engineers with chemical plant experience or chemical engineers, with broad experience of other branches of engineering and aptitude to co-ordinating specialist engineering activities will be considered.

Applications in writing.—BOX No. E8219, "The Engineer." A

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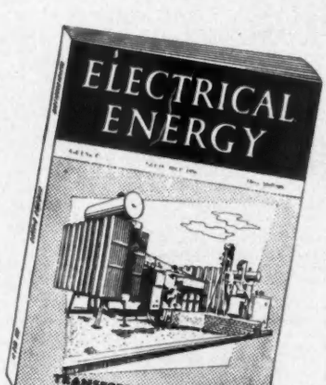

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CASTINGS.—We can save your porous castings, ferrous or non-ferrous, by an approved impregnation process ; sample castings treated ; A.I.D. approved. —Recupero, Ltd., 66, South Harrow Viaduct, Harrow, Middlesex ('Phone, Byron 1178). E109 MW

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PATENTS

THE PROPRIETOR of British Patent No. 731,332 for "FLUID FLOW CONTROL VALVES," desires to enter into negotiations with a firm or firms for the Sale of the Patent, or for the grant of Licences thereunder.—Further particulars may be obtained from Marks and Clerk, 57 and 58, Lincoln's Inn Fields, London, W.C.2. E8212 H

MISCELLANEOUS

A NEW RADIOGRAPHIC INSPECTION SERVICE.—GAMMAX, LTD., non-destructive testing specialists, provide Site or Laboratory, Radiographic Service. Manufacturers and suppliers of gamma and X-ray equipment and accessories.—GAMMAX, LTD., Cecil House, 47–51, Wharfdale Road, London, N.1. TER 0677–8 and 6925. E137 I

LET US HANDLE YOUR MECHANICAL OVERFLOW. Bills of Materials compiled from drawings ; progress and manpower schedules ; Inspection and Reports ; Equipment Lists., etc. U.K. and foreign experience.—Enquiries invitep BOX No. E2034, "The Engineer." I

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VICTORIA, S.W.1. Excellent Ground Floor Offices in new building. Floor area 4700 square feet. Central heating. Would divide into two units of 1700 sq. ft. and 3000 sq. ft. Also small suite of 3 offices nearby.—Full details from CHAMBERLAIN & WILLOWS, 23, Moorgate, E.C.2. (MET 8001). E8232 L

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WANTED, Machines of all Types.
CASH PAID.
Norman E. Potts (B'ham), Ltd., 130, Mousley Road, Birmingham, 12. VIC. 1278, 1279, 1270, 0856. E104 F

NORMALISING FURNACE for Steel Sheets, 9ft. by 4ft. by 0·3 to 4·0m.m. thick, 950 C., 2 tons per hour, gas and oil heated.—BOX No. E8170, "The Engineer." F

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LONDON DIVISION

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For permission to view and conditions of Tender, application to be made to the Divisional Purchasing Officer, London Division, Generation House, Great Portland Street, W.1, not later than the 1st September, 1958. E8236

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STEAM BOILERS.—Cochran Vertical (New). 8ft. 6in., 8ft., 7ft. 6in., 7ft. and 6ft. in dia., 100/150 lb. w.p.; reconditioned 8ft. 6in. down to 3ft. dia.; Economic 4ft. to 11ft. 6in. dia., including new 7ft. and 8ft. dia., 150, 180 and 200 lb. w.p.; 300 reconditioned Vertical Crosstube, all sizes.

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MACHINE TOOLS.—Scriven Plate Bending Rolls, 14ft. by ¾in.; Robertson Straightening Rolls, 8ft. 6in. by ¾in.; Berry Bending Rolls, 7ft. by ¾in.; Tangye 200-ton Hydraulic Vertical Straightening Press, 15ft. by 3ft. table ; Herbert 3ND Miller, 61in. by 15in. table ; Pels Punch and Shears, ¾in. capacity ; nine new 2 cwt. and 1 cwt. Pneumatic Hammers.

SLING ENGINEERING WORKS
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'Phone : Coleford 2271/2. E106 G

1. EDGEWICK NO. 2 UNIVERSAL MILLING MACHINE.
Working surface of table, 46in. by 11in.
Longitudinal travel, 25in.
Transverse feed, 7in.
Vertical feed, 16in.
Speed range, 24–405 r.p.m.
Feed range, ¼in.–9½in. per min.
Motor, 3 H.P., 440V., 3-ph., 50 c.
Low-voltage lighting transformer, 440V. in, 25V. out.
Vertical milling attachment and slotting head extra.
Gears for spiral cutting, but no dividing head.

2. MITCHELL LATHE.
Sliding, Surfacing and Screwcutting Lathe.
7in. centres, 36in. between centres.
All-geared headstock, giving 16 to 347 r.p.m.
Norton type feed and screwcutting gearbox, ranges : 2 to 28 T.P.I., and 0·006in. to 0·099in. feeds.
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With 12in., 4-jaw chuck, and electric suds pump.
Inspection invited by appointment with Appleby-Frodingham Steel Co., Reference P/EB, Scunthorpe, Lincolnshire. E8120 G

METROPOLITAN-VICKERS 500 H.P. SLIP-RING ELECTRIC MOTOR, 196 r.p.m., 400/440/3/50 cycles, complete with control panel and reduction gearbox, giving a final speed of 8·1 r.p.m.
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KEARNS OA HORIZONTAL BORING MACHINE with facing head and over-size table. Wartime machine.
H. BELL (MACHINE TOOLS), LTD.,
WALTER STREET, LEEDS, 4.
Tel.: 63–7398.
E105 G

Classified Advts. continued on page 104

FOR SALE

Edwards

BESCO High-Duty, Double-Geared Guillotine Shearing Machine, overcrank type, model "R," capacity 120in. by ¼in. mild steel, treadle-operated clutch, arranged motor drive for 400/440/3/50, length 120in., depth of gap 6in. Approximate weight 110 cwt.

NEW DEMONSTRATION MODEL BESCO High-Duty Double-Geared Guillotine Shearing Machine, overcrank type, model "R," capacity 72in. by ¼in. mild steel, arranged motor drive for 400/440/3/50, length of blade 72in., depth of gap 4in., fitted with automatic sheet hold-down. Weight approximately 100 cwt.

BESCO High-Duty Geared Guillotine Shearing Machine, overcrank type, model "R," capable of cutting mild steel plates up to 72in. wide by 3/16in. thick, arranged motor drive for 400/440/3/50, with automatic sheet hold-down, open ends in side frames enable plates of unlimited length to be trimmed. Weight approximately 59 cwt.

NEW BESCO Motor-driven Guillotine Shearing Machine, open-ended type, capable of cutting mild steel sheets up to 20 S.W.G. thick, motorised for 400/3/50, length of blades 36½in., with the top blade ground to a special angle the machine will cut fibre, plastics, mica, cardboard and similar materials. Approximate net weight 1036 lb.

BROOKES Power-Operated, Open-End Guillotine Shearing Machine, undercrank type, arranged motor drive for 415/3/50, capacity 49½in. by 16 S.W.G., depth of gap 2in., treadle-operated clutch. Weight approximately 10 cwt.

BRADLEY and CRAVEN Power Geared, Open-Ended Guillotine Shearing Machine, undercrank type, capacity 84in. by ¼in., gap in open ends 4½in., fitted with automatic sheet hold-down and adjustable gauges. Weight approximately 75 cwt.

Photographs of the above are available.

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Telephone : EUSton 4681–3771.
And at
LANSDOWNE HOUSE, 41, WATER STREET, BIRMINGHAM, 3.
Telephone : Central 7606–8. E207 G

NISSEN TYPE HUTS for sale. Prompt despatch of 16ft., 24ft. and 30ft. wide huts ; also "Romney" Huts, 35ft. wide, and "Blister" Hangars, 86ft. 6in. and 91ft. wide. These buildings are in various lengths and comprise steel framework with galvanised corrugated steel sheeting.—Full details from Dept. 115, J. Thorn and Sons, Ltd., Brampton Road, Bexleyheath, Kent (Tel., Bexleyheath 305). E113 G

FOR SALE

VALES PLANT REGISTER LIMITED

OFFER FOR IMMEDIATE SALE

ONE Jones "Super 20" Diesel Mobile Crane, Lister engine, 20ft. lattice jib, on pneumatics. New 1947. Good condition. £425.

One Neals NM 2-ton Diesel Mobile Crane, Ruston engine. New 1950. On crawlers, 25ft. jib. In good condition. £750.

One Jones "Super 40" 3-ton Mobile Crane, 24ft. jib, on pneumatics, Ruston engine. Good condition. £925.

One Neals QM 4/6-ton Diesel Mobile Crane, with 45ft. jib, on pneumatics, Ruston engine. New 1953. In good condition.

One Coles 6-ton Diesel/Electric Self-Propelled Mobile Crane, with 35ft. jib, on pneumatics. New 1948. In good condition.

One 5-ton Morgan Electric Derrick Crane, single-motor type, 100ft. jib, BESA machine. In good condition. £2200.

1 5-ton Grafton Diesel Rail Crane. New 1942. Perkins P6 engine, 38ft. jib, 4ft. 8½in. gauge. Reconditioned.

One 7-ton Anderson Grice 2-motor type Electric Derrick Crane, 120ft. jib. New 1951. With cabin. In very good condition.

One 7-ton Butters Steam Derrick Crane, 100ft. jib, double-drum type. Unused.

One 10-ton Henderson Steam Derrick Crane, 120ft. jib. First used 1954. In very good condition.

One 12½-ton Coles Fully Mobile Crane, with 45/80ft. jib. New 1950. £5500.

Further details, 14, Lower Grosvenor Place, London S.W.1. Telephone, VICtoria 7531, 3501, 8080, 9886 (15 lines). E107 G

FOR SALE

3-ton Taylor Jumbo Hydraulic Crane, diesel-driven.
1-ton Rapier Shop Truck Crane.
5-ton Coles diesel-driven self-propelled Mobile Crane on pneumatics.
5-ton Morris Versatile diesel/electric Mobile Crane on solid rubber tyres.
5-ton Smith Steam Loco. Crane 4ft. 8½in. gauge, 35ft. jib, new 1949.
6-ton Rapier Super petrol/electric Mobile Crane on solid rubber tyres.
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SEARCH (LIVERPOOL), LIMITED,
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TWW

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7in. CENTRES STANLEY MOTOR-DRIVEN LATHE, admit 3ft. between centres.

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NEW PREFABRICATED SECTIONAL TIMBER BUILDINGS

located at the premises of Messrs. Medway Buildings and Supplies, Ltd., Phoenix Wharf, Rochester, Kent, including 3 OFFICE BLOCKS 120', 104' and 16' × 24' × 8' to eaves; 7 OFFICE BLOCKS 40' × 24' × 8' to eaves; 10 MESS HUTS 56' × 24' × 8' to eaves, and a MESS HUT 24' × 24' × 8' to eaves, and

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Tenders, which must be in the form contained in the particulars, should be delivered to the Auctioneers at their Offices not later than 3 p.m. on the date mentioned above.

Catalogues with Form of Tender (and block plan of the Timber Buildings if required) may be obtained, when ready, of Messrs. FULLER HORSEY SONS & CASSELL, Industrial Auctioneers, 10 Lloyd's Avenue, London, E.C.3. E8165 J

FOR SALE

FOR SALE.—1 Sedgwick Plate Bending and Forming Brake Press, Size Reference No. Y-120. Full length capacity 10ft. by ¼in. mild steel plate of 28/32 tons tensile strength, up to depth of the gaps in the end frames, or 4ft. 2in. by ⅜in. mild steel plate.

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40-ton Adamson, standard cab control, 42ft 3in. span, 400/3/50.

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By Order of the Minister of Supply

GOVERNMENT SURPLUS STORES

SALES BY AUCTION

		Main Location	*Auctioneers*
Aug. 26–29	Machine tools, vehicles, and miscellaneous stores including:	M.O.S. Storage Depot, Royal Arsenal, Woolwich, London, S.E.18	FULLER, HORSEY, SONS & CASSELL (Dept. L), 10, Lloyd's Avenue, London, E.C.3. (Tel.: Royal 4861.)

48in. radial drilling machine, lathes, grinding machines, milling machines, shaping, slotting, engraving, drilling and hacksawing machines, Austin, Hillman and Humber light and heavy utilities, Bedford and Morris 1-ton and 3-ton trucks, Austin "Lodestars," Bedford and Morris tractors, saloon cars, scrap batteries, 12-ton ratchet jacks.

Diesel and petrol electric gen. sets, compressor plants, welders, overhead electric travelling cranes 10–40-tons cap., 42ft. 3in. span, fork lifts, industrial trucks, concrete sleepers, spares for self-propelled rollers, portable stone crushers and granulators, cold stores, Ruston Hornsby 4 VRO engines, gravity rollers, radio and electrical stores.

Clothing, footwear, 125,000 cap comforters, haversacks, 25,000 kitbags, 340,000 khaki worsted braid ties, 160,000 woollen short drawers, 36,000 woollen vests, 5,000 greatcoats, 145,000 sliding fasteners, 225,000 cops cotton and linen thread, 245,000 boot and button brushes, furniture, microscopes, prismatic binoculars, compasses, cameras, engineers' and carpenters' tools and outboard motors.

Sept. 3	Machine tools and miscellaneous stores.	Technical Stores Depot, Old Dalby, Melton Mowbray, Leicestershire (sale at Melton Mowbray).	SHOULER & SON (Dept. L), 1, Norman Street, Melton Mowbray, Leics. (Tel.: 81.)
Sept. 8–12	Passenger and load-carrying vehicles, earth moving and lifting equipment, motor cycles.	M.O.S. Storage Depot, Ruddington, Notts.	WALKER, WALTON & HANSON (Dept. L), Byard Lane, Bridlesmith Gate, Nottingham. (Tel.: 47271.)
Sept. 9	Miscellaneous stores.	General Stores Sub-Depot, Longtown, near Carlisle (sale at County Hall, Carlisle).	HARRISON & HETHERINGTON, LTD. (Dept. L), Botchergate, Carlisle. (Tel.: 26292)

Catalogues, 1s. 0d. each (P.O's only), available *only* from the auctioneers shown above.

SALES BY TENDER

(1) Bakery Plant located at Lingfield, Surrey.
(2) Bar and chucking autos., vertical borers, bench drills, centreless and internal grinders, lathes, manufacturing millers, gear shapers, etc., located at Sevenhampton, Wilts.
(3) Air Photographic Equipment comprising: stereo comparators type S.C.2 and processing unit 54mm. by 54mm. located at Woolwich.
(4) Hydrochloric Acid: Approximately 3500 galls. of pure HCl. and 9000 galls. of commercial HCl. located at Didcot, Berks, and New Ollerton, Notts.

Tenders must be submitted by September 1.

Applications for tender forms, stating which tender is required, should be made to the Ministry of Supply Directorate of Disposals, First Avenue House, High Holborn, London, W.C.1.

E118 J

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HYDRAULIC PRESSES

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2000-ton DOWN-STROKE HYDRAULIC FORGING PRESS, ram 31in. dia., admits 8ft. 7in. wide with horizontal sliding table, weight 200 tons.

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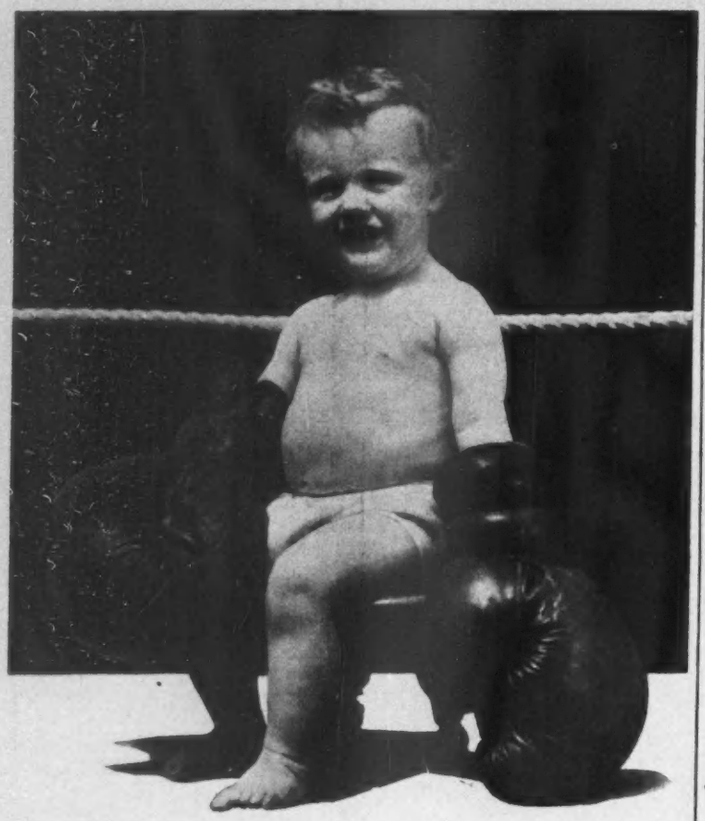

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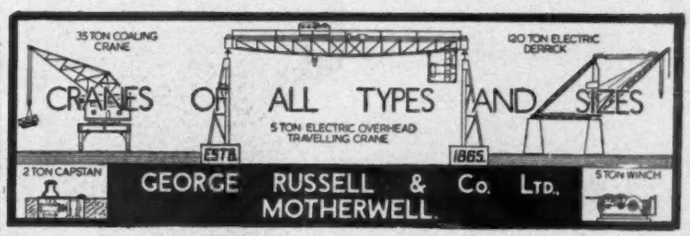

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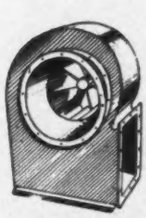

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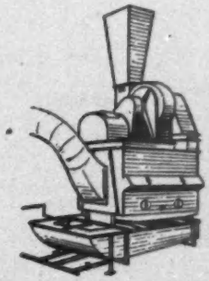

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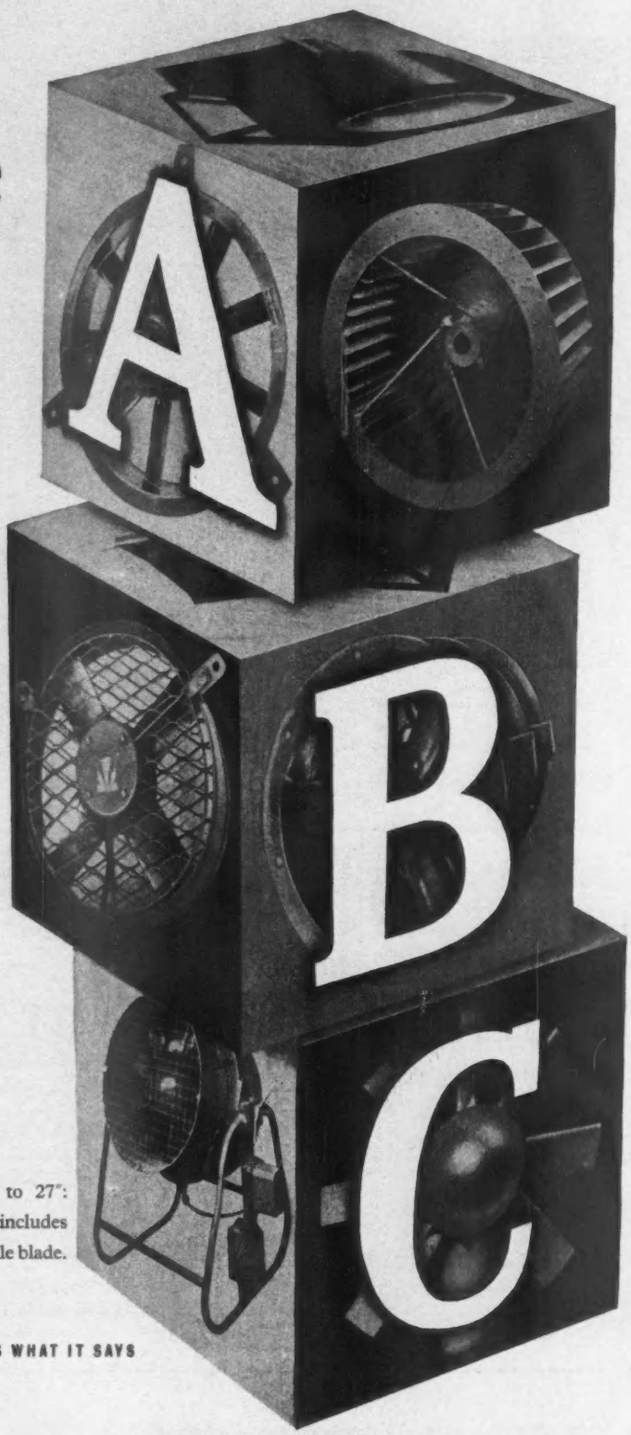

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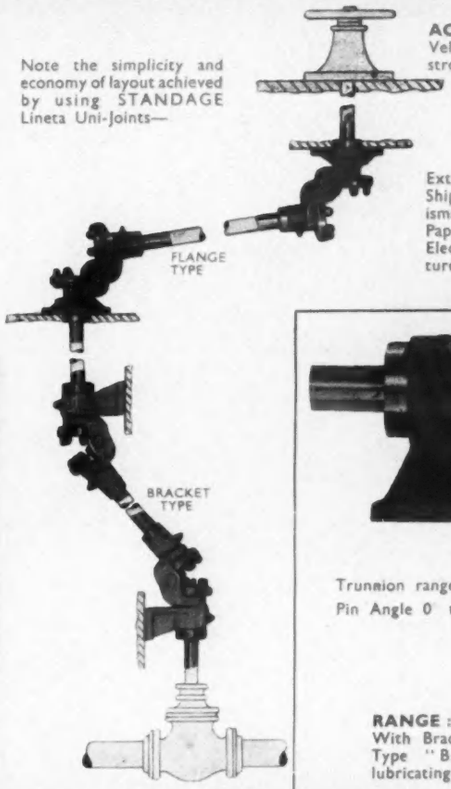

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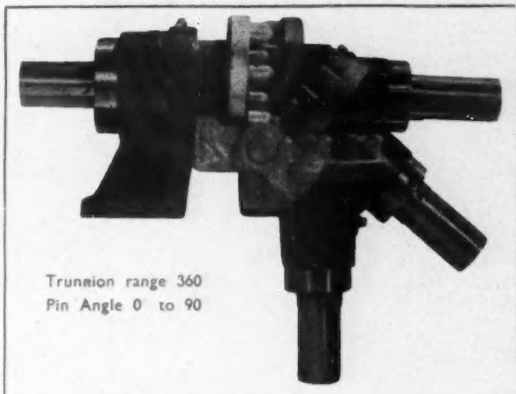

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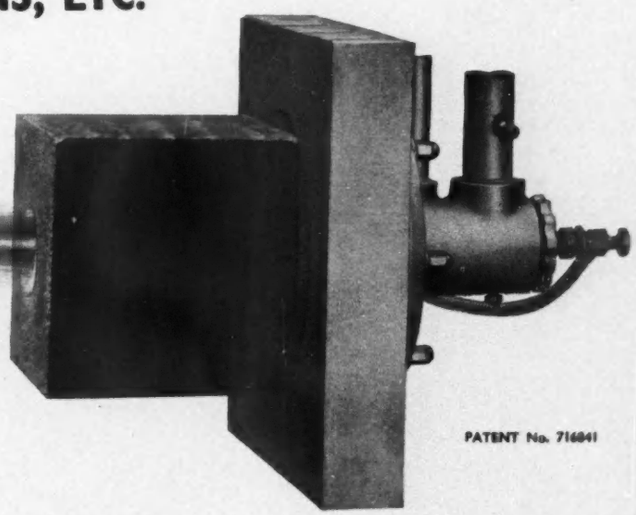

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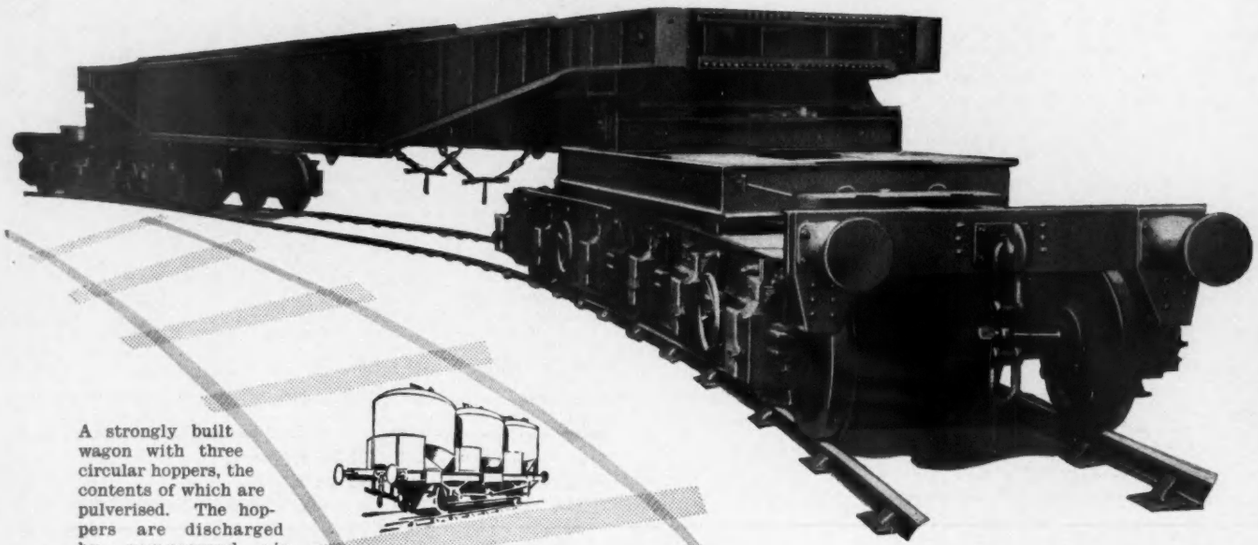
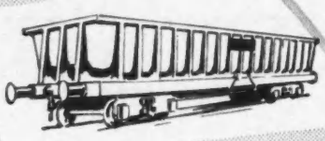
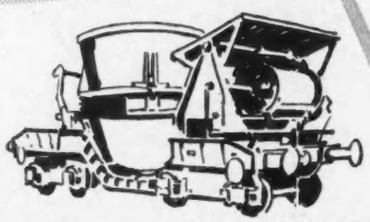


A strongly built wagon with three circular hoppers, the contents of which are pulverised. The hoppers are discharged by compressed air.

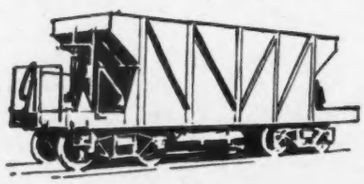
This robustly constructed transformer wagon can carry 135 tons and has four six-wheeled bogies.



This heavily constructed wagon is welded throughout, and designed primarily for carrying pig iron.



A welded steel carriage carrying a 400 cu. ft. Treadwell tipping slag ladle. Tipping is effected by means of steam or air.



Another example from the extensive range of Head Wrightson rolling stock, this bogie hopper wagon carries 40 tons and has transversely hinged doors.

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